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# Innovative Solutions to Human–Wildlife Conflicts

*National Wildlife Research Center Accomplishments, 2012*

**United States Department of Agriculture**
Animal and Plant Health Inspection Service
Wildlife Services

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The mission of the National Wildlife Research Center (NWRC) is to apply scientific expertise to resolve human-wildlife conflicts while maintaining the quality of the environment shared with wildlife. NWRC develops methods and information to address human-wildlife conflicts related to:

- agriculture (crops, livestock, aquaculture, and timber),
- human health and safety (wildlife disease, aviation),
- property damage,
- invasive species, and
- threatened and endangered species.

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**Cover Photo: A livestock protection dog keeps watch over his flock. NWRC researchers are investigating the use of larger European dog breeds for protecting U.S. sheep from wolves and other predators.**
*Photo by USDA, Anson Eaglin*

# Message from the Director

**Larry Clark, NWRC Director**
*Photo by USDA, Gail Keirn*

Today's Government continues to strive for smarter, more efficient, and leaner ways to conduct business. Some of the National Wildlife Research Center's (NWRC) efforts toward this goal are reflected in this year's accomplishments report. For example, our "spotlights" section highlights the importance of economics and economic analyses to wildlife damage management by looking at the costs and benefits of management related to invasive species, wildlife diseases, and agricultural pests. These types of analyses aid decisionmakers in understanding the economic risks of human-wildlife conflicts and the value of intervention management.

In addition, the report highlights efforts within the Wildlife Services (WS) program to cut costs and improve efficiencies. For example, in 2012, the WS management team decided to merge the National Wildlife Disease Program (NWDP) into NWRC. This change is reflected in our "spotlights" section dedicated to NWRC's wildlife disease research, surveillance, and international assistance. The merger is a natural consequence of a more integrated approach to wildlife disease surveillance and research, as well as the growing importance of this discipline to agricultural, human, and animal health and safety. In addition to the personnel and administrative efficiencies gained, the merger made sense from a functional perspective. NWDP is charged with coordinating WS' wildlife disease surveillance activities, emergency response efforts, wildlife disease-related training, and wildlife tissue archives. Many of these activities involve a great deal of research and methods development (e.g., developing optimal temporal and spatial surveillance strategies, as well as wildlife diagnostic methods). Thus, in February 2012, the two programs were merged with little disruption to program functions.

In addition to the NWDP-NWRC merger, other staff changes have made NWRC more efficient. At the beginning of fiscal year (FY) 2011, NWRC had reduced its FY 2010 staffing levels by 15 percent due to retirement and attrition. This reduction led to an overall evaluation of Center-wide priorities and resources, the elimination of some activities, and the combination of job responsibilities. Gene Rhodes, one of NWRC's two Assistant Directors, left the Center to become Director of the Savannah River Ecology Laboratory near Aiken, SC. His vacated position was filled after the NWDP-NWRC merger by Thomas DeLiberto, the former NWDP Coordinator.

NWRC remains committed to its other core mission areas of agriculture and natural resource protection, invasive species control, and product development. Product development takes center stage in this year's report with accomplishments organized by specific types of products and methods. This format provides an easy way for stakeholders and the public to see how their tax dollars are transformed into practical, cost-effective, and science-based tools and methods for use in wildlife damage management.

It is my privilege to introduce NWRC's accomplishments for 2012.

Dr. Larry Clark, Director
National Wildlife Research Center
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# Contents

# Research Spotlights

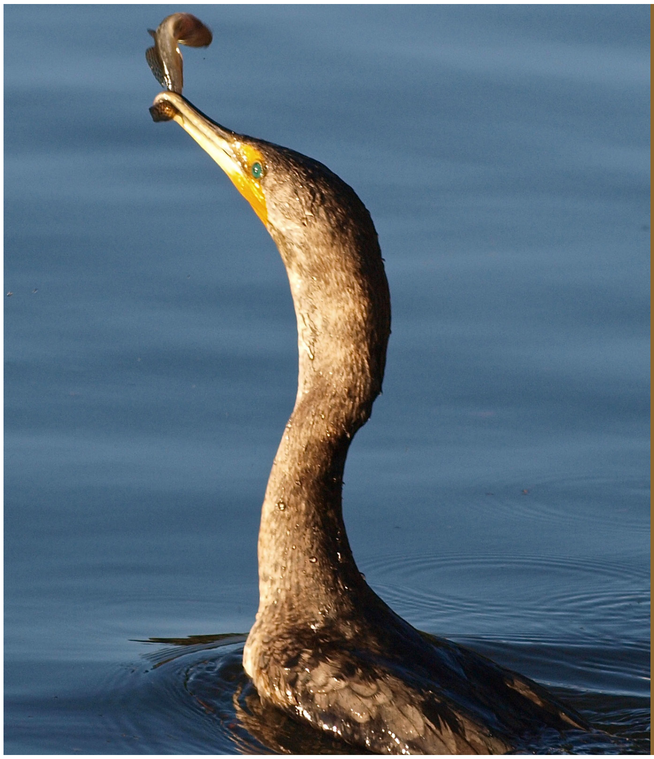
The National Wildlife Research Center (NWRC) is the research arm of Wildlife Services (WS), a program within the U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS). NWRC's researchers are dedicated to finding biologically sound, practical, and effective solutions to resolving wildlife damage management issues. The following four spotlights for 2012 show the depth and breadth of NWRC's research expertise and its holistic approach to address today's wildlife-related challenges.

## Spotlight: Economics of Wildlife Damage Management

Conducting research and developing methods for wildlife damage management can take years. Given the lag between discovering methods and actually using them, it is critical that managers and policymakers have a clear understanding of the process's costs and rewards. For Federal research laboratories such as NWRC, economic evaluations are increasingly important when justifying program dollars and showing value-added results to taxpayers. Members of the NWRC Economics Project have collaborated with WS' other research and operational areas to better define the economic risks of human-wildlife conflicts, show the value of intervention management, and translate wildlife management efforts into language that the public can understand—dollars and jobs. Economists use a variety of tools such as input-output models to extrapolate benefits and costs throughout local and regional economies and dynamic regional economic models to account for changes over time.

### Economic Benefits of Predation Management

Recently, NWRC economic modeling efforts have yielded significant insights into the value of wildlife damage management efforts related to predators, including fish-eating birds and invasive snakes. Many of these analyses are straightforward—estimating the benefits versus costs of various management actions. However, others involve more complicated modeling that must take into account species ecology, human behavior, or hypothetical situations. These more complicated analyses provide managers with a range of possible outcomes based on realistic assumptions.



**Cormorants are a significant predator of sportfish.**
*Photo by Flickr Commons, Ingrid Taylar*

**“The economic impact of wildlife damage, as it relates to dollars and jobs, is increasingly important to today’s decisionmakers.”**

NWRC economists determined the potential economic impacts of double-crested cormorant populations to New York sport fisheries. In 1998, WS Operations initiated an integrated pest management program to control the cormorant population at Oneida Lake, with the goal of decreasing cormorants’ consumption of walleye and yellow perch. To help decisionmakers evaluate the overall effectiveness of this program, NWRC economists conducted a benefit-cost analysis to compare the benefits of mitigating cormorant damage in the area with the overall costs of the program. They estimated the benefits to be equivalent to the value of fish and angler tourism in the Oneida Lake region. The estimated costs were based on direct cormorant management activities (e.g., employee salaries, equipment, etc.). NWRC’s analyses showed that from 1998 to 2005, for every $1 spent on WS cormorant management efforts, between $13 and $50 in revenue was saved in the Oneida Lake region. Management efforts also saved approximately 1,400–5,000 local jobs.

“Cormorant numbers continue to grow, and natural resource managers often come to Wildlife Services asking if management actions are worth the costs, especially when resources are scarce,” states Fred Cunningham, NWRC’s Mississippi Field Station Leader. “These types of economic studies help our collaborators make those important funding decisions.”

However, sometimes economic analyses and estimating the costs and benefits of wildlife damage management are not as simple or straightforward. For example, NWRC economists are often asked to estimate benefits and costs based on hypothetical situations, such as the potential expansion of invasive species like the brown treesnake. The brown treesnake has serious consequences to island ecosystems and their economies. Oceanic islands like the Hawaiian archipelago are more susceptible to

**If invasive brown treesnakes were to become established in Hawaii, studies show they could potentially cost the State up to $2.7 billion in lost tourism.**

*Photo by USDA, Laurie Paulik*

the impacts of invasive species than mainland areas because remote islands evolved in ecological isolation and have few predators or competitors, have a lot of air and sea traffic, and typically provide a favorable habitat and climate for many introduced species. In addition, native species on the islands have evolved in the absence of many introduced threats and usually respond poorly to invasive animals or diseases. Though the brown treesnake's economic and ecological impacts are well documented on the island of Guam, little is known about its potential impact on other Pacific Islands. In 2012, NWRC economists studied the likely economic consequences to the Hawaiian Islands if invasive brown treesnakes were to become established.

NWRC economists studied three categories of economic impact: medical treatments, electrical outages, and tourism losses. Because the brown treesnake's impact on the tourism sector of the economy had never been estimated before, the economists projected a hypothetical percentage range of decreased tourists (1 to 10 percent) using an input-output model. In order to more accurately define the range of potential tourist impacts from the snakes, NWRC conducted a survey in Oahu in January 2008. This survey elicited responses from U.S. and Japanese tourists about if and how they would alter their travels to Hawaii if the brown treesnake was present there. Survey results indicated that initial estimates of a 1-, 5-, or 10-percent decrease in tourism were conservative. Instead, survey results indicated that there would be between an 8- and 36-percent reduction in tourism. This tourism reduction would cause the Hawaiian economy to lose between $1 billion and $2.7 billion in revenue and between 9,780 and 18,800 jobs. These types of studies involving "what if" scenarios provide managers with context for making difficult intervention management decisions.

"We are concerned about the potential transportation of brown treesnakes to Hawaii," notes NWRC lead economist Stephanie Shwiff. "Like Guam, Hawaii has no endemic terrestrial snakes, and despite intensive cargo-screening measures to prevent the snake from leaving Guam, a few brown treesnakes have found their way to Oahu, hitch-hiking on aircraft from Guam. Economic studies, such as this one, are one way we can help decisionmakers see the potential benefits associated with various management and interdiction activities."

### Preventing Wildlife Rabies Saves Lives and Money

Rabies is an acute, fatal viral disease that can infect people and animals. The disease's impact on society can be great, especially in underdeveloped countries. The cost of detection, prevention, and control of rabies in the United States alone exceeds $300 million annually.

Approximately 90 percent of the reported rabies cases in the United States occur in wildlife. Raccoons and skunks account for the most reported cases, but bats, foxes, and coyotes are also among those commonly infected. Since 1995, WS has been working cooperatively with Federal, State, and local agencies; universities; and other partners to reduce rabies in wildlife. Each year, WS and cooperators distribute about 6.5 million oral rabies vaccination (ORV) baits in selected States to create zones where raccoon rabies can be contained.

NWRC economists have evaluated the value of WS' ORV efforts on several fronts. Initially, simulation models were developed to determine likely scenarios related to the spread of raccoon rabies if WS' ORV program were terminated. Based on these scenarios, economic models were then developed to determine the likely economic consequences of abandoning the ORV program. Economists estimated that an enhanced rabies program (i.e., one that pushes for the full eradication of the raccoon strain of rabies) would likely prevent an estimated $48 million to $456 million in rabies-related damages. Enhancing the ORV program was estimated to cost between $58 million and $158 million. Thus, the return on investment for national ORV programs in wildlife could be as high as $8 for every dollar spent.

On a more local scale, NWRC economists evaluated the return on investment of a coyote ORV program in Texas. From 1995 to 2006, south Texas implemented an ORV program to eliminate a rabies outbreak in


**Each year, WS and its cooperators distribute about 6.5 million oral rabies vaccine baits in selected States to create a zone where raccoon rabies can be contained. NWRC economists estimate that an enhanced rabies program (i.e., one that pushes for the full eradication of the raccoon strain of rabies) would likely prevent an estimated $48 to $456 million in rabies-related damages.**
*Photo by USDA, Jordona Kirby*

domestic dogs and coyotes. The cost of the 10-year program was approximately $26 million. However, an economic analysis estimated that the program's overall savings ranged from $89 million to $346 million in avoided damages, indicating that between $4 and $13 were saved for every dollar spent.

NWRC economists also collaborated with the California Department of Health Services to determine the direct and indirect economic costs of human rabies exposure in two California counties. Results indicated that the average cost of a single suspected rabies exposure was approximately $4,000. Using these identified costs, WS economists then assessed the potential benefits and costs of ORV baiting to eliminate or prevent the spread of skunk rabies in California. The results showed that for every dollar invested in wildlife rabies control and prevention, the return value in benefits could be as high as $6.35.

Results from analyses like these provide an economic basis for decisionmaking and serve as a guide for future ORV baiting campaigns in the United States and other countries.

## Wildlife Costs to Agriculture

Wildlife damage takes a large toll on U.S. agriculture. In 2002 (the most recent year for which data is known), USDA's National Agricultural Statistics Service estimated the annual cost of wildlife damage to agriculture was approximately $944 million. WS activities help reduce damage to livestock and aquaculture, as well as to fruit, vegetable, and grain crops.

California accounts for the majority of the annual U.S. production of avocados ($200 million) and wine grapes ($2.1 billion). In California, WS experts help to prevent rodent and bird damage to numerous crops, including avocados and wine grapes. WS reduces this damage by hazing animals with propane

**Birds and rodents can cause significant damage to fruit crops. In California, the net benefit of bird control to wine grape crops was estimated to be $956 to $1,600 per acre.**
*Photo by USDA/ARS, Bob Nichols*

cannons and using repellents, barriers, netting, and toxicants. NWRC economists calculated the net benefits of bird and rodent control on a per-acre basis and accounted for crop savings, property damage avoided, and control costs. In avocado production, the net benefit of bird control was estimated to be $60 to $196 per acre, and the net benefit of rodent control was estimated to be $574 to $1,117 per acre. In wine grape production, the net benefit of bird control was $956 to $1,600 per acre, and the estimated benefit for rodent control was $390 to $832 per acre.

Taking the analysis further, NWRC economists estimated the total impact of bird and rodent damage to the California economy due to decreased agricultural yields and increased pest control costs for 22 selected crops. Multiple economic models were integrated to estimate the economic impact to the State, including the use of an input-output model for a subset of California's 10 leading agricultural counties. The total estimated revenue lost annually in the 10 counties/22 selected crops due to bird and rodent damage ranged from $168 million to $504 million. The total estimated number of jobs lost annually ranged from 2,100 to 6,300.

Estimating the economic impacts associated with wildlife damage, including predation, disease, and crop loss, provides valuable information to decisionmakers about whether, when, and how much damage management is appropriate. The need for NWRC economic studies is expected to continue to grow in the coming years as more decisionmakers request information to aid in making difficult financial decisions.

**Next Steps**—Future NWRC economic analyses will examine the impact of wildlife-transmitted antimicrobial-resistant pathogens on livestock producers and regional economies. Key results will include the economic impacts of banning antibiotic use in livestock production, the potential emergence of antimicrobial-resistant pathogens, and the benefits of increased biosecurity measures at individual farms and regional levels. NWRC economists' studies will also focus on the benefits of wildlife hazard management at airports. NWRC economists will statistically analyze bird strike data to estimate the expected damages that result from a bird strike, as well as the probability of a bird strike occurring in areas with and without WS mitigation activities.

> "As worldwide trade and travel continue to grow, so too will challenges for natural resource managers, ecologists, and biologists dealing with invasive species."

## Spotlight: Invasive Species Impacts

It is estimated that invasive species cost the United States at least $120 billion per year in damages and control efforts. Many people are aware of the thousands of invasive plants and insect pests in the United States, but few may be mindful of the more than 1,000 invasive wildlife species that now call the United States "home." Invasive wildlife species can reduce biodiversity, degrade habitats, alter genetic diversity, transmit exotic diseases to native species, and further jeopardize threatened and endangered plants and animals. NWRC scientists' research aids in efforts to prevent invasive species introductions to the United States; detect and respond to invasions quickly and effectively; control, manage, and eradicate existing invasive species populations; enhance the restoration of native wildlife populations and habitats; and encourage international cooperation and the promotion of public education.

### Battling the Burmese Python

The Burmese python is an invasive species that has become well established in southern Florida. In some locations, it has become a top predator that feeds on native wildlife and out-competes native species. Currently, there is no active operational control program focused on systematically detecting and removing Burmese pythons from southern Florida. If the python population continues to grow, it will likely have substantial impacts on native wildlife populations, with impacts potentially most pronounced on endangered species.

NWRC scientists are investigating new methods for monitoring and controlling Burmese python populations. Beyond its ecological impacts to native wildlife in southern Florida, land managers and scientists have expressed concerns about the python's potential to occupy other parts of the United States. However, recent findings by NWRC scientists and others cast doubt on the ability of free-ranging Burmese pythons to establish and persist beyond the subtropical environment of southern Florida. NWRC researchers are developing models that will help describe the Burmese python's population growth in Florida as it relates to thermal regulation and environmental temperatures. Results from these modeling efforts will better define the Burmese

**NWRC researchers provide training to other biologists on how to handle invasive Burmese pythons. These invasive snakes are increasing in numbers and expanding their range in Florida.**

*Photo by USDA, Eric Tillman*

python's ability to expand its range, which will help identify native ecosystems at risk and subsequent management strategies to protect them.

NWRC scientists are also investigating ways to improve trapping success as a means to reduce the python population. Researchers at the NWRC Florida field station initiated a study to assess pythons' reactions to a prey (rat) scent trail as a means to enhance trap success. The pythons' behavior was recorded with digital video cameras during six behavioral trials. Initial recordings indicate that the snakes are attracted to rat-scented trays, which may serve as an effective lure during live trapping or baiting activities.

In conjunction with the study above, NWRC scientists also evaluated trapping modifications made to enhance the capture success of pythons. In studies with captive snakes placed one at a time in a 10- by 30-foot test pen and monitored remotely with a digital video camera and a motion-activated trail camera, the scientists found that although a passive drift fence helped guide captive snakes to traps, its practicality for field use is limited. In a separate study, two live traps were placed in a python test pen; one trap was covered with black plastic, while the other was covered with burlap. In all cases, snakes entered the trap wrapped in black plastic. The researchers hypothesized that the snakes entered the trap with black plastic because they perceived it as a refuge. This finding could potentially improve the trapping success of wild pythons in Florida.

## Ensuring Safe Rodent Eradication Efforts

Rodenticides are used to eradicate invasive rodents from islands throughout the world. In 2011, the Palmyra Atoll Rainforest Restoration Project—composed of the U.S. Fish and Wildlife Service, The Nature Conservancy of Hawaii, and Island Conservation—attempted to eradicate rats from Palmyra Atoll (a remote island in the Pacific Ocean, approximately 1,000 miles south of Hawaii) in an effort to enhance the biodiversity of seabirds, native plants, and terrestrial invertebrates. The eradication effort was implemented by distributing Brodifacoum 25W Conservation, a rodenticide bait containing the second-generation anticoagulant rodenticide brodifacoum, by air and ground application. Because the eradication effort used an APHIS pesticide label and implementation of the control operation required a label variance, the coalition contracted NWRC to monitor the eradication operation's environmental effects. NWRC scientists measured the application rate and bait distribution on the ground following aerial application and documented the fate of bait; collected potential nontarget mortalities; and systematically collected soil, water, insects, geckos, fish, and crabs to determine environmental residue levels.

"Our goal was to help our partners evaluate any secondary hazards associated with the eradication effort. We found the overall rodenticide application rate to be within the limits specified by the Environmental Protection Agency's approved supplemental label," said William Pitt, a research wildlife biologist with NWRC's Hawaii field station. "However, we did document bait in the aquatic environment and found considerable variation in the amount applied over small localized areas. Bait may have ended up in the aquatic environment due to shoreline configuration, island topography, overhanging vegetation, bird activity affecting flight lines, wind strength and direction, pilot experience, and weather conditions at the time of the drop."

NWRC researchers found rodenticide residues in ants, cockroaches, geckoes, hermit crabs, fiddler crabs, and black-spot sergeant fish that were collected alive as part of scheduled environmental sampling activities during and after bait application.

**NWRC scientists and partners measured the application rate and bait distribution of a rodenticide during a rodent eradication effort on Palmyra Atoll in the Pacific.**
*Photo by USDA, Tom McAuliffe*

Fifty-one animal samples representing 15 species of birds, fish, reptiles, and invertebrates were found dead and collected for residue analysis during systematic searches or collected opportunistically as potential nontarget mortalities during routine activities throughout the atoll. The NWRC researchers detected rodenticide residues in 12 of 15 birds that were found dead on or around the atoll after the broadcast application. Affected avian species included bristle-thighed curlews, Pacific golden plovers, ruddy turnstones, and wandering tattlers. Affected non-avian species included mullet fish and *Cardisoma* spp. land crabs. It is likely that nontarget exposure to the rodenticide was a result of direct consumption of bait and secondary exposure through scavenging of poisoned rat carcasses.

More than one live rat was detected in July 2011, necessitating a third broadcast application of bait containing a rodenticide over part of the atoll. Rats have not been detected after the final broadcast. Monitoring for the presence of rats will continue through the summer of 2013 to determine whether rat eradication has been achieved. This type of collaboration, evaluation, and monitoring is critical to the success of the current project as well as future eradication projects.

## New Tools for Feral Swine Management

Feral swine are an increasing problem in the United States and around the world. They destroy native vegetation, prey on wildlife and livestock, and transmit diseases to humans and livestock.

When responding to disease outbreaks, livestock owners, disease experts, and natural resource managers often reduce infected or susceptible animals through culling. In the event of a catastrophic disease outbreak such as foot-and-mouth disease or classical swine fever, a means for containing free-ranging feral swine would be crucial to the safety of the U.S. livestock industry.

In the United States, current culling and population management techniques for feral swine include recreational harvest, aerial gunning, trapping, and snaring. NWRC researchers are working to improve existing tools and develop new tools for managing feral swine. These efforts include developing and registering an oral toxicant, investigating new trapping techniques, and studying feral swine movement and behavior.

In a continuing effort to find new management tools for use with feral swine, NWRC researchers are collaborating with Australian scientists in the development and registration of a new oral toxicant called HOG-GONE®, which contains lethal doses of sodium nitrite.

“Sodium nitrite may be the ‘Achilles Heel’ of feral swine because of their sensitivity to this substance relative to many other mammals,” notes NWRC’s research wildlife biologist Tyler Campbell. “Since we currently do not have any toxicants registered for use with feral swine in the United States, we’re very interested in evaluating its effectiveness here, but we're also concerned about potential nontarget hazards."

To better understand the relative sensitivities of feral swine, raccoons, and white-tailed deer to sodium nitrite, an NWRC scientist conducted oral gavage trials at the Kerr Wildlife Management Area in Texas. Results showed that raccoons were more sensitive and expired more readily than swine or deer after ingesting sodium nitrite. Deer were the least sensitive to it. Researchers believe the sensitivity of raccoons and white-tailed deer is such that they are at low risk of intoxication when sodium nitrite-based baits (i.e., HOG-GONE) are coupled with swine-specific delivery systems. Research continues on HOG-GONE with an emphasis on reducing nontarget risks and developing swine-specific delivery systems.

Without an effective registered toxicant in place, trapping continues to be one of the primary methods for controlling feral swine. Currently, numerous trap designs are used to capture feral swine; however, until recently, drop nets have not been evaluated. In a study conducted in Oklahoma between 2010 and 2011, NWRC scientists compared the effectiveness and efficiency of a drop net and a traditional corral trap for trapping feral swine. A mark and recapture analysis showed more swine were removed with drop nets than with corral traps. Efficiency estimates for the average time per capture were 1.9 hours for drop nets and 2.3 hours for corral traps. Feral swine did not appear to exhibit trap shyness around drop nets, which often allowed the researchers to capture entire family units in a single drop. The use of drop nets also eliminated the capture of nontarget species. The results of this study indicate that drop nets are an effective tool for capturing feral swine.

**NWRC studies indicate that drop nets are an effective tool for capturing feral swine.**

*Photo by USDA, Tyler Campbell*

It is important to consider how feral swine respond to control operations when developing optimal management plans. To better understand feral swine behavior, NWRC scientists studied the effects of baiting on feral swine movements and the likelihood that baiting would reduce swine dispersal under culling pressure on the Rob and Bessie Welder Wildlife Foundation (WWF) in San Patricio County, TX. By placing global positioning system collars on feral swine, scientists were able to track their movement throughout control operations. Population-wide culling activities included trapping and shooting around a centralized bait station. Feral swine home ranges did not differ between the bait station site and other non-baited sites. However, the daily movement rates of feral swine at bait station sites were 39 percent greater than the movement rates of animals in non-baited areas.

> **“Wildlife disease monitoring helps prevent widespread and damaging disease outbreaks in humans and domestic animals.”**

“Opposite to what we thought might occur, baiting stations did not reduce movement in our treatment areas,” states NWRC research wildlife biologist Tyler Campbell. “We do not recommend the use of baiting as an alternative to fencing for containing feral swine during culling activities.”

**Next Steps—**NWRC will continue its research efforts related to feral swine, rodents, pythons, and other invasive reptiles. In particular, there is a strong need for safer, more effective rodenticides and a selective toxicant for feral swine. NWRC researchers are exploring methods to increase the efficacy of rodenticides while also reducing the toxicity levels found in bait. Efforts are underway to test the efficacy of sodium nitrite as a toxicant not only for use with feral swine but also rodents. Work related to Burmese pythons includes a new procedure to detect python DNA in water. The ability to detect python DNA may prove useful for monitoring free-ranging pythons in the wild. Researchers are also investigating the food habits and impacts of invasive black spiny-tailed iguanas and Argentine tegus to native wildlife, as well as developing new traps and toxicants for these species.

## Spotlight: Disease Surveillance in Wildlife

The majority of pathogenic infectious diseases—such as bovine spongiform encephalopathy, foot-and-mouth disease, West Nile virus, severe acute respiratory syndrome (SARS), and highly pathogenic H5N1 avian influenza—are caused by pathogens transmitted between wildlife, domestic animals, and humans. More than 72 percent of these zoonotic diseases (diseases that can be passed from animals to humans) have emerged or reemerged within the last three decades and were caused by pathogens with a wildlife origin. These statistics epitomize the increasing and significant threat that zoonotic diseases pose to global health and the importance of understanding and managing such diseases in wildlife populations.

It is generally recognized that countries conducting wildlife disease surveillance are more likely to understand the epidemiology of specific infectious diseases and zoonotic outbreaks. As a result, these countries are better equipped and prepared to develop solutions that will protect humans, agriculture, and wildlife. As such, and in accordance with Homeland Security Presidential Directives, WS created the National Wildlife Disease Program (NWDP) in 2003 to conduct national wildlife disease surveillance activities. As a unit within NWRC, NWDP staff work collaboratively with WS Operations specialists to provide the only comprehensive, nationally coordinated system in the United States for conducting wildlife disease surveillance and emergency response activities. NWDP’s strategy is based on the premise that safeguarding the health of humans, animals, and ecosystems ensures safe agricultural trade and reduces agricultural and natural resource losses. NWDP’s efforts also provide an early warning system for the emergence of zoonotic diseases that have the potential to cause epidemics or pandemics in humans, as well as domestic and wild animals.

In Fort Collins, CO, NWRC biologists and veterinarians coordinate NWDP's monitoring and surveillance programs for over 70 pathogens, diseases, and toxins. They develop disease-specific monitoring and surveillance plans at regional, national, and international scales. These plans are distributed to WS wildlife disease biologists located across the country who are responsible for obtaining biological samples and shipping them to the appropriate diagnostic laboratories. WS wildlife disease biologists also serve as liaisons to other State, Federal, and tribal agencies concerned with wildlife disease issues and assist them in accomplishing their disease surveillance objectives. In addition, these biologists serve as WS' first responders during wildlife-related emergencies such as disease outbreaks and natural disasters.


**Since 2008, NWDP has sampled over 7,000 feral swine in 35 States for foreign animal diseases.**
*Photo by USDA*

The summaries below highlight NWRC's efforts related to monitoring foreign animal diseases in feral swine, plague, and avian influenza and discuss how the information is used in research.

### Feral Swine Disease Surveillance

Experts estimate that there are approximately 5 million feral swine in the United States. Feral swine not only cause extensive damage to agriculture and natural resources; they can also carry or transmit over 30 diseases and 37 parasites that pose a threat to agricultural and human health. Although diseases such as classical swine fever, foot-and-mouth disease, and African swine fever are not currently found in the United States, feral swine could spread these diseases to domestic swine or other susceptible animals if they entered the United States.

Since 2008, WS employees have collected over 7,000 feral swine samples in 35 States to test for foreign animal diseases as well as endemic diseases, such as brucellosis, pseudorabies, influenza, trichinosis, Hepatitis E virus, and *E. coli* 0157:H7, as part of the Feral Swine Comprehensive Disease Surveillance System. Many of the samples were collected from feral swine living in close proximity to domestic swine facilities because these animals pose a higher risk of introducing a foreign animal disease into a domestic population. These samples are used to conduct risk analyses for (1) disease transmission to domestic swine and (2) the early detection of emerging diseases such as influenza. The Feral Swine Comprehensive Disease Surveillance System reported the first cases of pandemic H1N1 influenza virus in feral swine during 2010 and the first feral swine case of the H3N2 influenza virus that infected people in 2012. Prior to establishing this surveillance system, no organization had been successful in isolating these or any other influenza viruses from feral swine.

## Plague

One of the first disease monitoring and surveillance systems developed by NWDP was the National Plague Surveillance System. Plague is caused by the flea-borne bacterium *Yersinia pestis.* Though it can be transmitted to humans, plague is primarily a disease of rodents. Unfortunately, many plague-infected rodents survive exposure or have limited to no clinical symptoms at all, which can make disease detection difficult. However, some carnivores that are resistant to developing disease when exposed to infected rodents or their fleas can serve as effective sentinels of plague activity. In particular, coyotes—which have relatively large home ranges and are regularly part of wildlife damage management efforts—can serve as cost-effective sentinels for plague activity in an area.

NWDP conducts plague surveillance, which helps determine plague exposure in wildlife on a national scale, gain a better understanding of transmission dynamics and the risk of human exposure, and predict epizootics of the disease. Initial analyses of data from Arizona show a temporal relationship between the number of human plague cases and coyote seroprevalence rates for the disease. From 2005 to 2011, WS employees collected 46,801 blood samples from coyotes and other carnivores across the country to test for exposure to *Y. pestis.* NWRC scientists are analyzing these samples to determine if local and regional patterns in wildlife exposure to plague correlate with disease outbreaks.

## Avian Influenza

"No other disease has brought wildlife surveillance to the forefront of people's minds like avian influenza," notes Thomas Deliberto, former NWDP coordinator and current NWRC Assistant Director. "In 2006, Wildlife Services led an effort to sample for the highly pathogenic avian influenza virus in wild birds, as well as in lakes and ponds across the country. This effort shed new light on how avian influenza viruses circulate in the wild and what can be done from a biosecurity standpoint to protect agricultural operations and humans."

As part of the U.S. National Strategy for Pandemic Influenza, WS participated in the development and implementation of an Interagency Strategic Plan for the Early Detection of Highly Pathogenic H5N1 Avian Influenza in Wild Migratory Birds in 2006. The purpose of the plan was to create a national system

**From 2006 to 2011, more than 490,000 samples from wild birds were collected as part of a national surveillance effort for highly pathogenic avian influenza.**
*Photo by USDA*

for detecting highly pathogenic avian influenza viruses (HPAIV)—specifically the H5N1 subtype—in migratory birds. While the immediate concern was a potential introduction of HPAIV H5N1 into the United States, the system was developed to detect any HPAIV in migratory waterfowl regardless of the source. In addition, the system increases knowledge regarding low-pathogenic avian influenza viruses (AIV) and the general health of wild birds. The system was used to develop flyway and State-specific HPAIV surveillance strategies by establishing guidelines consisting of standardized protocols for sampling wild birds, handling and shipping samples, diagnostic testing, and communicating results.

From April 2006 through March 2011, Federal and State biologists collected over 491,000 samples from wild birds in the United States. Thankfully, no HPAIV were detected. Taking advantage of this large sample size, NWDP scientists conducted a "freedom of disease analysis." This analysis provided the United States and its trading partners confidence that the early detection system was capable of detecting HPAIV even if fewer than 5 wild birds out of a population of over 50 million waterfowl were infected.

NWRC researchers and collaborators have also taken advantage of the large data set to develop risk assessment models for U.S. poultry operations and network analyses that reveal connectedness among populations and geographic areas. These models and analyses are useful for optimizing surveillance and detection strategies for AIV.

### Wildlife Tissue Archives

In 2005, WS established wildlife tissue archives. The archives' diverse contents are derived from the Interagency Highly Pathogenic Avian Influenza Early Detection System for Wild Birds, routine surveillance for diseases carried by feral swine, and plague and tularemia monitoring in wildlife. The collection is unique in its quantity of samples (more than 300,000 wild bird samples alone), diversity of species, broad geographic range, and consistent sampling effort over extended periods of time. The archives support numerous types of studies, including emerging disease diagnoses, wildlife health studies, assay method validation, and a variety of retrospective studies. Some recent examples include the study of the distribution of avian bornavirus in wild birds, the validation of a portable field polymerase chain reaction system for avian influenza detection, and the study of parasite transfer between pasture-raised domestic pigs and feral swine. NWRC welcomes inquiries about using archive tissues for studies. Please contact NWRC via email at nwrc@aphis.usda.gov for additional information.

**Next Steps—**NWDP recently initiated a national monitoring project for raccoon roundworm in raccoons with the Southeastern Cooperative Wildlife Disease Study, Florida Fish and Wildlife Conservation Commission, and Idaho Department of Fish and Game. The project objectives are to determine the apparent prevalence and distribution of *Baylisascaris procyonis* in raccoons at a national scale; identify and document factors associated with *B. procyonis* expansion; correlate human cases with infection rates in wildlife and domestic animals; and compile risk assessment maps for humans living in endemic areas. NWRC researchers and collaborators are analyzing approximately 1,000 raccoon samples, with results to be published in 2013.

## Spotlight: International Collaborations

WS and its research arm, NWRC, have a long history of working with international partners to address wildlife damage management issues. At one time, the Denver Wildlife Research Center, precursor to NWRC, had international research stations and field facilities in 10 countries. Work out of these

**“International partnerships open new doors of discovery for wildlife management and research.”**

facilities, along with numerous shorter consultancies, helped foreign universities establish wildlife damage management courses and programs for vertebrate pest control in multiple countries. Although long-term international research projects have become a rarity, NWRC continues to engage in considerable international activity particularly related to training and consultation. NWRC has the necessary expertise to manage problem wildlife species, resolve critical wildlife damage situations, plan and implement surveillance programs, and design programs to meet ecological requirements and regulatory constraints. NWRC scientists have lent their experience to fostering research and helping to resolve wildlife conflicts worldwide. Many of these scientists serve on international committees that address solutions to universal wildlife problems or assist cooperating universities with graduate student training. Below are examples of NWRC's international collaborations.


**NWRC collaborations with researchers from Argentina and Uruguay led to meetings in the United States aimed at reducing bird damage to agricultural crops.**
*Photo by USDA, Jeff Glans*

## Supporting Partners Through Training

Each year, NWRC hosts international visitors for training purposes or cooperative projects. In 2012, 77 visitors representing 15 countries (Argentina, Australia, Canada, China, Great Britain, India, Indonesia, Japan, Kenya, Mexico, Russia, Turkey, Ukraine, Uruguay, and Vietnam) spent time at NWRC's headquarters campus in Fort Collins, CO. At the request of visitors, subject matter experts within NWRC frequently provide specialized training on topics related to wildlife damage management, including invasive species, crop and livestock protection, airport hazards, and aquaculture. While some of these training sessions consist of brief overviews on these topics, NWRC also offers longer, more indepth workshops that often focus on the detailed aspects of specific topics. For example, NWRC conducted three workshops on wildlife disease surveillance in conjunction with delegations from Ukraine and China during 2012. Two workshops occurred in the United States, and one workshop occurred in China. NWRC scientists, along with other APHIS experts, provided seminars and led discussions to further develop wildlife disease surveillance capacity in those countries.

Foreign scientists who have obtained advanced degrees while conducting research projects in conjunction with NWRC often return after they graduate to collaborate on subjects of common concern to their country and the United States. In 2012, scientists from Uruguay and Argentina met with NWRC scientists to continue expanding collaborations on bird depredation research that originated when they were graduate students. The visit resulted in a renewed effort between NWRC and Argentina's National Institute of Agriculture Technology to collaborate on common wildlife damage management issues.

NWRC's international collaborations also lead to the discovery of tools and technologies developed in foreign countries that may be applicable for use in the United States. NWRC scientists are currently working with experts from Australia to evaluate the Australian-made toxicant bait called HOG-GONE® and the HOG-HOPPER® oral delivery system to help manage damage and disease threats from invasive feral swine. If successful, these new tools would greatly enhance U.S. efforts to manage feral swine.

Where possible, to save resources, NWRC has curtailed international travel and relied on other forms of communication to develop and maintain collaborations and exchange information. However, NWRC was able to send scientists to a few targeted locations, primarily regional and global meetings with the potential to reach broad audiences or multiple collaborators. In all, 10 NWRC employees visited 15 different countries during fiscal year 2012. Scientists attended meetings in Canada, China, France, Great Britain, Italy, Mexico, South Africa, and Turkey. The U.S. Department of Defense's Defense Threat Reduction Agency sponsored the meeting in Turkey to develop a cooperative threat reduction directorate. An NWRC wildlife veterinarian attended the meeting, providing insight on the role that wildlife species have in spreading or maintaining disease threats and offering potential cooperative activities to combat these threats. In addition, NWRC conducted regional workshops on wildlife disease issues in Peru and China. NWRC staff also interacted with cooperating scientists on ongoing surveillance or research projects in Cambodia, Indonesia, Spain, Switzerland, Uganda, and Ukraine. Travel to Spain was funded by Spain's National Wildlife Research Institute to assist with developing methods to reduce the transmission of bovine tuberculosis from wildlife to livestock in Spain—primarily by evaluating means to keep wildlife from using water and other resources meant for cattle. An NWRC scientist also worked with colleagues in Switzerland to evaluate a new technology that alerts herders when livestock are stressed by predators.

### Memorandum of Understanding With Chinese Academy of Sciences

NWRC experts helped to develop and implement a memorandum of understanding (MOU) between the Chinese Academy of Sciences, the Bureau of Life Sciences and Biotechnology, and WS to promote ongoing cooperation.


**NWRC biologists train foreign scientists in disease surveillance techniques.**
*Photo by USDA, Heather Sullivan*

“Wildlife Services has a strong relationship with the Chinese Academy of Sciences,” notes Dale Nolte, NWRC Program Manager and International Liaison. “This MOU will focus on wildlife disease issues, including identifying harms and risks posed by wildlife disease that threaten agriculture or have zoonotic implications; developing a joint consortium to address emerging disease issues in wildlife populations; identifying risks and developing management approaches to mitigate zoonotic disease impacts; promoting global awareness of harms and threats posed by emerging wildlife diseases; and developing activities to enhance the region’s capacity to respond to emerging wildlife diseases.”

The MOU also specifies collaborative work to identify harms and risks posed by wildlife to agriculture, natural resources, aviation, and human health and safety, as well as to promote the development of methods and management approaches to reduce those risks. Since May 2010, a bilateral working group consisting of experts from both the Chinese Academy of Sciences and WS has agreed to host biannual regional conferences on wildlife diseases in Asia, collaborate on surveillance activities for wildlife-borne diseases, develop an Asia-Pacific wildlife disease network, and provide training to the Chinese State Forestry Administration on conducting wildlife disease activities.

### Long-Term Disease Surveillance and Research

During the last several years, NWRC’s NWDP has conducted wildlife disease surveillance or training for people from over 30 countries in Asia, Africa, and South America. Although direct involvement in most of these countries has been greatly reduced, there continues to be an exchange of information and collaborative interaction. NWDP continues to serve as a national associate on the Food and Agriculture Organization of the United Nation’s Scientific Task Force on Wildlife Diseases. Efforts are currently underway to finalize graduate student projects on disease transmission in Indonesian wildlife markets. In addition, collaborative projects continue with Colorado State University to identify diseases in bats and potential wildlife reservoirs for Chikungunya viruses in Cambodia.

Most recently, NWRC scientists began collaborating with multiple partners to investigate wild swine’s role in the spread of African swine fever to domestic swine. In the Ukraine, NWRC is collaborating with USDA’s Foreign Agricultural Service and Ukrainian authorities to conduct disease surveillance in wildlife—particularly European wild boar. Specific project objectives include strengthening Ukraine’s wildlife management and disease surveillance program, promoting the effective and efficient use of collected field samples to broaden the surveillance of animal diseases, and strengthening existing response efforts to emerging disease outbreaks in wildlife. In return, NWRC also hopes to gain firsthand experience in the surveillance and control of African swine fever. In another related project, NWRC is collaborating with the Southern Research Institute to address the Ukraine’s capacity to collect and process wild boar samples to test for African swine fever and classical swine fever.

NWRC is also collaborating with partners in Uganda and Kenya to better understand the impacts of African swine fever to native wildlife species such as bushpigs and warthogs. Collaborations with Makerere University and Swedish Agricultural University will apply a molecular ecological approach to understand the bushpigs’ role in the epidemiology of the African swine fever virus at the wildlife-livestock interface in Uganda. In addition, NWRC is collaborating with the U.S. Army Medical Research Unit-Kenya, Central Veterinary Laboratories-Kabete, the International Livestock Research Institute, and others to investigate African swine fever and potential disease risks to desert warthog and wild pig populations in northeastern Kenya.

**Next Steps—**In 2013, scientists will continue to exchange ideas and share information with existing and potential collaborators around the globe.  NWRC is working with the Chinese Academy of Sciences to develop plans for an international workshop on wildlife diseases in Fort Collins, CO.  In addition, collaborative efforts will continue with Australian scientists to assess the potential for incorporating toxicants and a delivery system currently used to control feral swine in Australia into the U.S. management program.  NWRC will collaborate with USDA's Foreign Agricultural Service to conduct site visits and hold a workshop on wildlife damage management in the Ukraine, with an emphasis on addressing African swine fever in wild swine.  NWRC will also continue cooperative surveillance activities in China and its collaborative efforts with Colorado State University to assess wildlife species in Cambodia as potential reservoirs of diseases such as Chikungunya that may emerge in the United States.

# 2012 Accomplishments in Brief

NWRC employs approximately 150 scientists, technicians, and support staff who are devoted to 15 research projects (see Appendix 1). Below are brief summaries of select findings and accomplishments from 2012 not previously mentioned in this year's report.

## Pesticide Development

- **Zinc Phosphide: Increasing the Acceptance of Baits.** Lowering pesticide concentrations in rodenticides and other baits is important in efforts to reduce the amount of these compounds in the environment. However, lower concentrations of pesticides in the formulations can also lead to the development of bait shyness in target animals before effective dosages can be achieved. Reducing bait shyness in voles is critical to successful rodent management. In 2012, NWRC evaluated two approaches for reducing zinc phosphide bait shyness in bait formulations: (1) formulating baits with zinc phosphide encapsulated with a polymethacrylate coating to prevent oral detection of zinc phosphide and (2) suppressing the bitter taste by adding zinc sulfate and sodium cyclamate to the bait. Zinc sulfate blocks taste receptors for bitter and natural sweeteners, while the artificial sweetener, sodium cyclamate, makes the bait taste sweet even in the presence of zinc sulfate. Zinc phosphide baits formulated at a low concentration routinely produced bait shyness even when zinc sulfate and sodium cyclamate were added. However, microencapsulating zinc phosphide improved efficacy. Encapsulated zinc phosphide resulted in 80-percent vole mortality when formulated at 0.5 percent, a significantly lower concentration than the 2 percent that is currently being used.
  *Project Contact: Bruce Kimball*

- **Anticoagulant Risks.** The U.S. Environmental Protection Agency (EPA) has placed new regulatory restrictions on the use of some second-generation anticoagulant rodenticides in the United States, and in some situations these restrictions may be offset by the expanded use of first-generation compounds. NWRC scientists conducted several studies with captive adult American kestrels and Eastern screech-owls that examined the toxicity of diphacinone (DPN) for acute oral and short-term dietary exposure regimens. DPN evoked intoxication and mortality at doses that were 20 to 30 times lower than reported from the traditionally used wildlife test species. Sublethal exposure of kestrels and owls resulted in prolonged clotting time, reduced hematocrit, and/or gross and histological evidence of hemorrhage. Findings also demonstrated that the DPN was far more potent in short-term, 7-day dietary studies than in single-day acute oral studies. These studies indicated that the risks associated with DPN exposure to raptors are far greater than predicted in analyses that principally used data from mallards and bobwhite quail. These findings can assist natural resource managers in weighing the costs and benefits of anticoagulant rodenticide use in pest control and eradication programs.
  *Project Contact: Bruce Kimball*

**Voles have become resistant to some rodenticides, leading to a renewed interest in rodenticide development.**
*Photo by USDA*

**Common Mynas are an invasive species in the United States and other parts of the world.**
*Photo by USDA, Michael Avery*

- **Efficacy of a Cholecalciferol Plus Diphacinone Bait for California Voles.** NWRC researchers determined the efficacy of a new cholecalciferol plus diphacinone bait for use with California voles in California agricultural fields where they have developed resistance to chlorophacinone bait. In no-choice tests with captive voles, results showed that the pelleted bait was highly effective (100-percent mortality). Subsequent two-choice tests also showed a high efficacy (80-percent mortality). Field efficacy trials are being planned.
*Project Contact: Gary Witmer*

- **DRC-1339 Use With Mynas.** The Common Myna is an aggressive invasive bird species that damages crops, creates nuisance problems, and threatens native bird species in many countries. In collaboration with officials in American Samoa, NWRC scientists evaluated the toxicity of the registered pesticide DRC-1339 as a potential tool for myna management. The acute oral LD50 (the dose needed to kill 50 percent of a sample population) was 1.19 milligrams of DRC-1339 per kilogram of body weight. According to the EPA's classification, DRC-1339 would be classified as 'very highly toxic' to Common Mynas on an acute oral basis. In a second trial, NWRC scientists demonstrated the efficacy of lethal bait (cooked white rice treated with DRC-1339) to captive mynas. Based on the findings from these trials, plans are underway to conduct a field efficacy study in support of registering DRC-1339 for use in America Samoa.
*Project Contact: Michael Avery*

## Repellent Development

- **Earthworm Repellents and Aviation Safety.** At airports, earthworms frequently come to the surface and move onto runways and taxiways after rain storms. These earthworms attract birds, which in turn increases the risk of bird-aircraft strikes. Developing effective earthworm controls would help reduce aviation hazards. An NWRC scientist recently identified ammonium sulfate fertilizers as effective repellents for reducing the number of earthworms on study plots.
*Project Contact: Travis DeVault*

## Device Development

- **Coda Netlauncher© for Capturing Birds.** NWRC scientists evaluated three modified net configurations for use with the Coda Netlauncher to help improve its ability to capture birds. NWRC researchers modified the nets to make them as light and as large as possible, while still maintaining the strength necessary to withstand repeated launching and capture stresses. The initial cost of a Netlauncher—which includes a standard and remote detonator, one modified net, a toolkit, and 20 charges—was about 50 percent more than a box-type rocket net, but the cost of operating the device was lower. Capture success rates of the modified nets varied from 25 to 69 percent and were comparable to those reported for other capture methods. The Netlauncher with modified nets proved to be a relatively cost-, labor-, and time-efficient tool in comparison to other capture techniques. Because the Netlauncher does not use combustive or explosive propellants, it provides managers with a lightweight, flexible method for capturing birds with simplified training and reduced regulatory oversight.
  *Project Contact: Fred Cunningham*

- **Using Bud Caps To Protect Seedlings.** During reforestation after harvest or natural disturbances such as fire, trees are most vulnerable to wildlife damage during the first 5 years of growth. Scented bud caps are a tool used to protect young seedlings from deer and elk damage during stand initiation. The lightweight, paper devices slide over terminal leaders of seedlings, providing a thin deterrent to curious and hungry ungulates. The devices are also infused with a chemical repellent to aid in seedling protection. A goal of protecting terminal leaders is to maximize the vertical growth rate, thus promoting "free to grow" conditions that allow seedlings to become part of a vigorous, healthy forest. NWRC scientists evaluated the efficacy of scented bud caps to prevent damage to Douglas fir seedlings by black-tailed deer and Roosevelt elk in an area of western Washington that received historically high levels of seedling damage. Results from a 2-year controlled study indicated that the use of bud caps did not increase conifer seedling survival or height growth. Deer and elk were the primary causes of seedling damage; however, scientists also noted that several seedlings were clipped at their bases by rabbits, which were an unsuspected source of damage by foresters in this area.
  *Project Leader: Jimmy Taylor*

**NWRC research indicates that the use of bud caps to protect seedlings from browsing animals does not increase conifer seedling survival.**
*Photo by USDA*

- **Bait Delivery for Brown Treesnakes.** In cooperation with Applied Design Corporation, a private engineering firm, NWRC scientists designed an automated aerial bait delivery system for use with the invasive brown treesnake. The first phase of the system's development is complete and consists of the bait delivery device. Additional components that remain to be developed include the design of bait package manufacturing equipment, integrated helicopter electronics, and integrated software systems. Once completed, this aerial delivery system will allow for the economical delivery of toxic brown treesnake bait to large, remote, and rugged areas of Guam.
  *Project Contact: William Pitt*

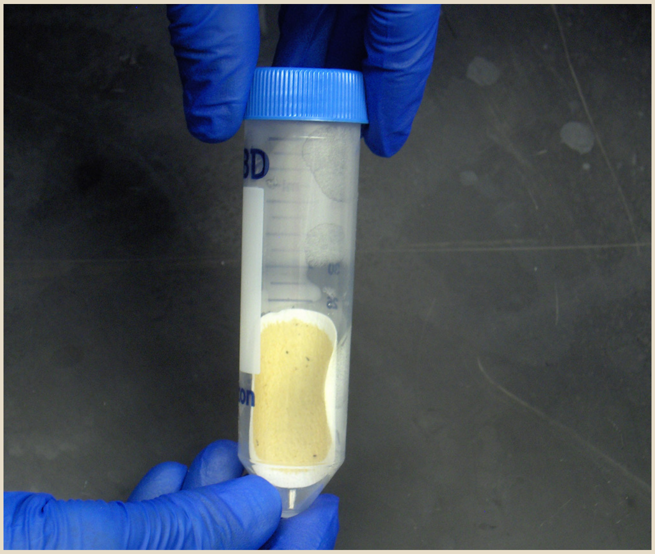
**NWRC field studies are evaluating potential nontarget hazards associated with a new feral swine toxicant and delivery system.**
*Photo by USDA*

- **Modification of the Swine HOG-HOPPER® To Minimize Nontarget Hazards.** Feral swine are responsible for crop damage, wildlife predation, habitat destruction, and the spread of livestock and human diseases. Scientists in several countries are developing new tools to control feral swine damage. One such tool is sodium nitrite, an oral toxicant that causes methemoglobinemia and rapid death in feral swine. Before registration of this toxicant can proceed in the United States, nontarget risks must be assessed. In a recent study, NWRC scientists evaluated bait removal rates for feral swine and nontarget animals using nontoxic bait and the HOG-HOPPER, a simple device developed to prevent access to bait by nontarget animals. NWRC and its Wildlife Services (WS) operational collaborators performed 38 field trials in Alabama, Florida, Oklahoma, and Texas. Preliminary findings indicate that bait removal declined for feral swine between the prebaiting period when the HOG-HOPPER was open and the post-treatment period when the device was closed and bait could only be removed by animals sliding the door open. Bait removal also declined for raccoons; however, raccoons were able to breach the HOG-HOPPER and access bait during 4 of the 28 trials. In all of these trials, the duration of the prebaiting period was greater than 30 days. NWRC experts believe this long prebaiting period allowed raccoons to learn how to operate the HOG-HOPPER door. No breaches were observed for other species, including white-tailed deer, striped skunks, opossums, and coyotes. NWRC will submit data from the study to EPA as part of an APHIS request for an experimental use permit for field trials involving toxic HOG-GONE® bait, which contains lethal doses of sodium nitrite.
  *Project Contact: Tyler Campbell*

- **Visual Barriers To Manage Deer Behavior at Airports.** Visual obstructions such as barriers or fences often enhance white-tailed deer vigilance and flight-initiation distances, presumably because they increase the deer's sensitivity to predation risk. NWRC scientists deployed feeding stations surrounded by 1.5-meter high, polyethylene barriers on three sides. Fewer deer used these feeding stations in comparison to feeding stations without barriers. Deer that did use the partially enclosed stations showed increased alert behavior

**Burrowing ground squirrels can interfere with security systems at nuclear missile silos. NWRC researchers are testing various barrier systems to prevent ground squirrel access to military sites.**

*Photo by USDA, Rachael Moulton*




**NWRC researchers concluded that the Nobuto® blood strips did not detect antibodies for West Nile virus as often as whole blood samples and, therefore, may not be an effective alternative for use in field sampling.**

*Photo by USDA, Richard Engeman*

(e.g., their heads were held above horizontal, their ears were erect, their body posture was noticeably stiff, they paused, they flagged their tails, or they fled). This study suggests that visual barriers may offer a temporary and easily manipulated means of diminishing deer's use of resources at unfenced airports. *Project Contact: Travis DeVault*

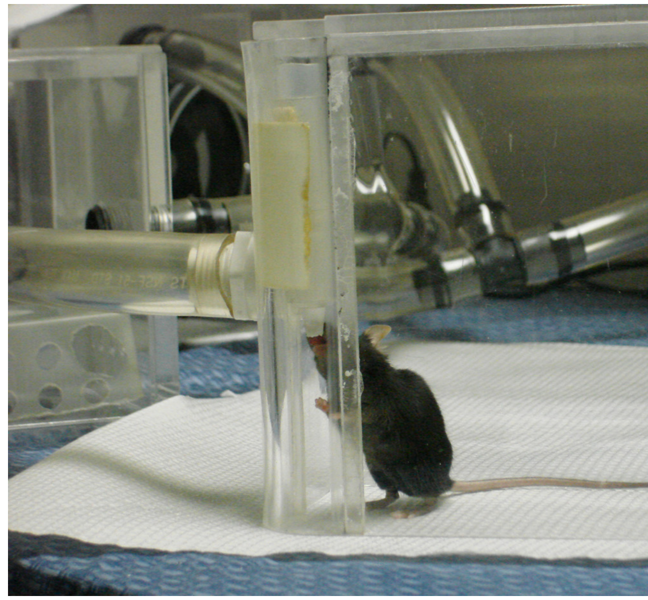
- **Preventing Rodent Damage at Nuclear Missile Silos.** Burrowing rodents can interfere with security systems at nuclear missile sites. At the request of Malmstrom Air Force Base, NWRC scientists identified the hazards that rodents pose to security systems and developed prototype barrier systems to eliminate burrowing rodent intrusions. NWRC is currently evaluating one potentially useful system that is composed of trenches filled with hardware cloth or pea gravel coupled with an aboveground barrier of clear polycarbonate plastic. *Project Contact: Gary Witmer*

## Disease Diagnostics and Other Methods Development

- **Evaluation of the Nobuto® Blood Strip for West Nile Virus Surveillance.** Processing whole blood from wild birds for seroprevalence of West Nile virus (WNV) in the field can be challenging, time-consuming, and expensive. Therefore, NWRC researchers evaluated the use of commercially available Nobuto blood filter strips as an alternative method for collecting whole blood. In this study, NWRC collected blood samples from approximately 40 experimentally infected red-winged blackbirds using both Nobuto strips and traditional serum samples. Both sets were analyzed using current serological screening tests to see if WNV-specific antibodies could be detected. Nobuto strips did not detect WNV antibodies as often as whole blood samples, which led NWRC researchers to conclude that Nobuto blood strips may not be an effective alternative for use in field sampling as part of large-scale WNV antibody surveillance studies. *Project Contact: Alan Franklin*

- **Detection of Volatile Organic Compounds and Bacterial Nucleic Acids in Animals as Tools for Diagnosing Bovine Tuberculosis.** Volatile organic compounds (VOCs) are organic compounds that often emit unique odors and emission patterns. Because of these unique characteristics, VOCs have been identified as potential tools in disease surveillance. Recently, NWRC scientists and colleagues from APHIS-Veterinary Services, the Tel-Aviv University, and Technion-Israel Institute of Technology developed a method for collecting and analyzing VOCs from cattle. The scientists tested the method during an outbreak of bovine tuberculosis (bTB) in cattle. Gas-chromatography and mass-spectrometry analysis revealed the presence of two VOCs associated with a bTB infection in the exhaled breath of infected cattle. Based on these results, a nanotechnology-based array of sensors was then tailored for detection of bTB-infected cattle via breath. The system successfully identified all bTB-infected animals, while only 21 percent of the noninfected animals were classified as bTB-infected. This technique could form the basis for a real-time cattle monitoring system that allows efficient and noninvasive screening for new bTB infections on dairy farms.
  *Project Contact: Kurt VerCauteren*

- **Analyzing Body Odor To Determine Immunization Status.** Infections can alter body odor in ways that may be useful for disease diagnosis. Since an animal's immune system generally activates in response to an infection, researchers believe it may respond similarly to an immunization, thus causing alterations in body odors that are detectable either by trained biosensor animals or headspace gas chromatographic analyses. In a series of experiments, an NWRC researcher successfully trained mice to distinguish between urine odors of rabies-vaccinated (RV) mice and non-vaccinated mice. The trained mice were also able to distinguish between urine from mice immunized with an equine WNV vaccine and urine from corresponding controls, indicating that the training was not specific to the immunizing agent. To further investigate the specificity of odors, immune system processes, and the usefulness of chemometric methods for diagnostic purposes, NWRC researchers tested the urine of mice treated with lipopolysaccharide (LPS) using a new biosensor panel of mice that was trained to detect RV mice. The trained biosensor panel did not generalize to the odors of LPS-treated mice. Chemometric analyses classified RV samples as different from control samples and LPS-treated mice as similar to RV mice. Thus, although bioassay and chemometric analyses exhibited some differences, both demonstrated that immunization alters the body's volatile patterns in ways that can be detected by smell and/or chemometric techniques.
  *Project Contact: Bruce Kimball*



**Scientists have trained mice to distinguish between the odors of vaccinated and unvaccinated mice.**
*Photo by Monell Chemical Senses Center, Maryanne Opiekun*

- **Noninvasive Monitoring of Avian Influenza in Birds.** Avian influenza viruses (AIV) pose significant hazards to agriculture and human health. Rapid and accurate detection of infected organisms is

critical to monitoring and preventing the spread of AIV. To achieve this goal, NWRC researchers and collaborators trained six biosensors (inbred mice) to identify feces collected from ducks infected with low-pathogenic avian influenza based on fecal volatiles. Mice were exposed to fecal odors, but contact with feces was not allowed. The trained mice correctly discriminated the health status of individual mallards by identifying feces from post-infected periods when paired with pre-infected feces. Fecal samples were also subjected to dynamic headspace and solvent extraction analyses employing gas chromatography/mass spectrometry. Chemical analyses indicated that infection was associated with a marked increase of acetoin (3-hydroxy-2-butanone) in feces. These experiments suggest that the health status of water-fowl can be evaluated noninvasively by monitoring of volatile fecal metabolites. Furthermore, environ-mental monitoring using trained biosensor animals or portable instrumentation may be an effective tool for assessing an animal population's health.
*Project Contact: Bruce Kimball*

- **Detecting CWD From Cerebrospinal Fluid.** NWRC researchers evaluated whether cerebral spinal fluid (CSF) could be used to diagnose chronic wasting disease (CWD) in elk. As part of the evaluation, NWRC collected the CSF from 6 captive and 31 free-ranging adult elk at necropsy and evaluated it for the presence of CWD via protein misfolding cyclic amplification (PMCA)[1]. In addition, each animal's obex was examined by immunohisto-chemistry. Four of the six captive animals were CWD-positive and euthanized due to signs of termi-nal CWD. The remaining two were CWD-negative. None of the 31 free-range animals showed overt signs of CWD, but 12 tested positive for CWD by immunohistochemistry. PMCA only detected CWD in three of the four captive animals showing clini-cal signs of CWD. Furthermore, PMCA did not detect CWD in any of the nonclinical animals that tested positive by immunohistochemistry. NWRC researchers concluded that CWD prions can be de-tected in the CSF of elk but only relatively late in the course of the disease. Therefore, the use of PMCA with CSF could be used as a confirmatory test for CWD, but it should not be used as a diagnostic tool.
*Project Contact: Kurt VerCauteren*

- **Use of Infrared Thermography To Detect Rabies in Bats.** The use of modern technology, including infrared thermography, in disease surveillance provides opportunities for insights into pathogen emergence, prevention, and control. This technology should have the capacity to identify diseased individuals within a population that are potentially manifesting clinical signs. NWRC researchers conducted a study that evaluated the use of infrared thermography to detect thermal changes associated with experimental rabies virus infection in big brown bats in a captive colony. Results indicated that when bats began to show clinical signs of rabies, 54 percent had detectable facial temperature decreases, compared to pre-inoculation temperatures. As a result, researchers believe that infrared thermography may be a useful noninvasive tool for use in rabies surveillance in bats.
*Project Contact: Kurt VerCauteren*

## Wildlife Damage Assessments

- **Egret Impacts on Aquaculture.** It is important to document the impacts of wildlife on commodity production to determine the damage magnitude and patterns. This information is critical to efficiently allocate resources when developing mitigation mea-sures. NWRC scientists analyzed the diets of great egrets foraging in catfish farms in the Mississippi Delta. The biomass of great egrets' stomach

[1] PMCA is an amplification technique similar to polymerase chain reaction but involves misfolded proteins (versus nucleotides).

**Research has shown that bird damage to commercial sunflower crops is influenced by nearby land cover types (e.g., wetlands, pasture, and forest).**
*Photo by USDA, George Linz*

contents consisted of catfish (86.44 percent), shad (13.26 percent), bream (0.16 percent), and mosquito fish (0.14 percent). NWRC is conducting additional research to determine if the catfish consumed by great egrets were healthy or sick. Great egrets readily consume catfish and potentially warrant the use of wildlife damage management actions.
*Project Contact: Fred Cunningham*

- **Bird Damage to Corn and Sunflowers.** North Dakota is the top sunflower-producing State in the United States, harvesting about 405,000 hectares (1 million acres) annually. Up to 63 percent of this crop is grown in central North Dakota in the Prairie Pothole Region. Since the early 2000s, corn has become a major crop in the region due to the development of hybrids capable of growing in more northern areas. Corn production in North Dakota has doubled over the last decade to 900,000 hectares. Blackbirds damage both ripening corn and sunflowers. Three decades have passed since North Dakota's last Prairie Pothole Region damage survey. Given the changes that have occurred in crop composition within the region, NWRC scientists felt compelled to update bird damage assessments for corn and sunflowers. In addition to field damage assessments, NWRC conducted land cover analyses to determine if land features were associated with blackbird damage. Over the 2-year study period, the average damage to sunflowers (2.1 percent) was higher than the damage to corn (0.3 percent). Cumulative 2-year damage estimates were 15 metric tons for sunflowers and 13 metric tons for corn, with an economic value of $6.3 million and $2.0 million, respectively. Sunflower damage was greatest (11 percent) in the Southern Drift Plains of the Prairie Pothole Region, where the least amount had been planted. Land cover composition consisting of mostly bean crops and wetlands showed the greatest relationship with sunflower damage, while the amount of open land showed the greatest significance in relation to corn damage. The results of this study provided data that will help producers make informed decisions about crop selection and location.
*Project Contact: George Linz*

**Captive Canada geese forage in turf plots as part of a preference study at the NWRC Ohio field station.**
*Photo by USDA, Thomas Seamans*

**Green roofs, those partially or completely covered in vegetation, are becoming increasingly popular in urban environments.**
*Photo by USDA, Brian Washburn*

## Management Strategies

- **Managing Turf at Airports To Prevent Bird Strikes.** Because of their large size and flocking behavior, Canada geese pose a serious threat to aviation safety. Previous NWRC research has shown that grazing Canada geese do not consume endophyte-infected tall fescue. Grasses containing endophytic fungi have several benefits, such as resistance to both grazing and insect herbivory, heat and drought stress tolerance, and increased vigor. Over 200 varieties of turf-type tall fescue are currently available from the turfgrass industry for use in airfield revegetation projects. NWRC scientists identified several commercially available tall fescue cultivars, including Titan LTD, 2nd Millennium, and Crossfire II, which grow successfully in airport environments but are not a preferred food source for geese.
  *Project Contact: Travis DeVault*

- **Stormwater Impoundments as Hazards to Aviation Safety.** The design of privately owned stormwater impoundments on or near airports has received little attention, yet it has a profound influence on the type and abundance of birds near airports and subsequent bird airstrike hazards. NWRC scientists developed models of habitat use by birds posing the highest risks for airstrikes. The scientists found that broad reductions in the use of stormwater impoundments, located within or near airports, by bird species hazardous to aviation can be achieved via designs that minimize perimeter, surface area, and the ratio of emergent vegetation to open water.
  *Project Contact: Travis DeVault*

- **Airport Grasslands, Biodiversity, and Safety.** Airport grasslands attract bird species known to be hazardous to aircraft; however, they have also been proposed as candidates for biodiversity conservation. NWRC scientists conducted analyses to ascertain whether airport grasslands would be candidates for biodiversity conservation. Their analyses determined that the potential for airports to serve as conservation areas for grassland birds is limited, as the habitats needed for successful conservation would often increase the number of hazardous species and subsequent aviation safety risks.
  *Project Contact: Travis DeVault*

- **Green Roofs in an Airport Environment.** Green roofs, whether partially or completely covered in vegetation, are becoming increasingly popular in urban environments. Questions remain as to whether they attract wildlife or contribute to airstrike hazards when located near an airport. An NWRC scientist found that wildlife's use of green roofs is limited to a few avian species, including killdeer, European starlings, and mourning doves, and occurs primarily during the summer. These findings indicate that the presence of green roofs at airports will likely have little impact on aviation safety.
*Project Contact: Travis DeVault*

- **Modeling DRC-1339 Mortality Estimates.** DRC-1339 is a slow-acting avicide used to reduce local populations of European starlings, blackbirds, and other nuisance birds. It is difficult to accurately estimate the number of birds killed with DRC-1339 because carcass searches and other types of counts are not accurate predictors of take at staging area bait sites. To improve mortality estimates associated with current linear models and DRC-1339 use, NWRC scientists developed a semi-mechanistic model that combines the mechanistic modeling of environmental and biophysical processes with the statistical modeling of DRC-1339 toxicities, avian physical and physiological traits, and foraging behavior. The scientists used simulated baiting scenarios in Missouri and Louisiana to compare take between the two models. Compared to the linear model, the semi-mechanistic model estimates ranged from 5 percent higher to 59 percent lower, depending on the species and gender compositions of the blackbird flocks. On average, the new model's estimates were 24 percent lower than the linear model. Unlike the linear model, the new model accounts for the effects of meteorological and environmental conditions that likely influence feeding rates at DRC-1339 bait sites. NWRC researchers believe that the semi-mechanistic model represents a more scientifically rigorous approach toward estimating take that can be applied to all staging area bait applications regardless of the region or time of year.
*Project Contact: George Linz*

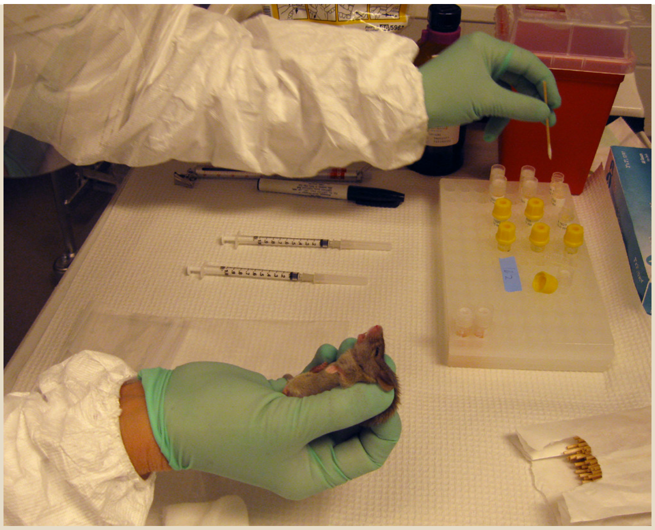
- **Starling Movements in Agricultural and Suburban Environments.** To gain a better understanding of the site use and movement patterns of starlings using DRC-1339 bait sites in agricultural landscapes impacted by suburban sprawl, NWRC scientists captured and radio tagged a total of 50 starlings at 1 rural site and 2 sprawl-impacted sites in central New Jersey. The scientists assessed whether the behaviors of wintering starlings using these landscapes could lead to more effective strategies for reducing public encounters with poisoned birds. Most birds using the rural site ranged no more than a few kilometers from their capture site and were onsite almost daily over the 40-day study period. The majority of this group also used the site as a roost. In contrast, birds captured at the two sprawl-impacted sites ranged farther from their capture sites and showed less daily fidelity. In addition, onsite roosting was infrequent. Starlings using sprawl-impacted sites targeted for DRC-1339 baiting were most likely using them as supplemental foraging sites and not focal points of daily activity. However, areas with high bird activity were generally less than 6 kilometers (3.7 miles) from these supplemental sites. Most roost sites were less than 10 kilometers (6.2 miles) from the capture sites and occurred in undeveloped habitat patches, such as parks, small stands of evergreens, and emergent-dominated wetlands. When going to roost, the radio-tagged birds usually headed on a direct bearing to the roost site. Considering the sensitivities associated with public encounters with poisoned birds, researchers recommend using alternative methods for starling removal when baiting in suburban agricultural areas.
*Project Contact: George Linz*

- **Optimizing Cormorant Management.** The double-crested cormorant is a native North American waterbird that recently expanded its population dramatically. Population control efforts in the United States and Canada attempt to mitigate cormorant damage to natural resources and aquaculture. However, there is currently no coordination among the various stakeholders involved in management activities as well as no attempt to optimize population control efficiency. For the first time ever, NWRC scientists modeled how individual management strategies combined with demographic and ecological factors might affect cormorant populations at various spatial scales and over time. The majority of current management operations are undertaken when colonies are near or at carrying capacity. In contrast, NWRC's models predict that management is most efficient when it is applied to colonies earlier (below carrying capacity) and to more central colonies. Management appears less efficient when colonies are closer to or at carrying capacity. These NWRC-developed simulation tools provide insights into the efficiency gain that can be expected from the coordinated planning of management activities.
*Project Contact: Fred Cunningham*

## Wildlife Surveillance and Ecology

- **House Mice, Rabbits, and Striped Skunks as Potential Disseminators of Low-Pathogenic Avian Influenza Virus.** AIV are known to infect a number of mammal species, several of which are commonly found on or near poultry and gamebird farms. In a series of studies with captive house mice, cottontail rabbits, and striped skunks, NWRC researchers investigated the potential role of these mammal species in shedding AIV. The researchers trapped and sampled house mice on a gamebird farm in Idaho that had recently experienced a low-pathogenic avian influenza outbreak. All of the six house mice caught on the outbreak farm were presumptively positive for antibodies to type A influenza virus. Consequently, NWRC researchers experimentally infected groups of naïve wild-caught house mice with five different low-pathogenic AIV,

**NWRC scientists are studying how various management strategies affect local and migratory movements of double-crested cormorants.**
*Photo by USDA*



**In captive studies, wild house mice were found to be competent hosts for low pathogenic avian influenzas, thereby making them a potential pathway for movement of the virus.**
*Photo by USDA, Susan Shriner*

**Hundreds of thousands of invasive European starlings can descend on cattle feeding operations, consuming feed intended for livestock, defecating in feed bunks and water troughs, and spreading disease.**
*Photo by Nick Dunlop (freelance photographer)*

which included three viruses derived from wild birds and two viruses derived from chickens. AIV replicated efficiently in wild-caught house mice without adaptation, indicating that mice may be a risk pathway for movement of AIV on poultry and gamebird farms. In two captive studies involving the inoculation of cottontail rabbits and striped skunks with H4N6 AIV, results showed that all exposed animals shed the virus through various routes, indicating that these species could potentially play a role in the transmission of AIV.
*Project Contact: Alan Franklin*

- **European Starlings and Coccidia.** To investigate the relationship between European starlings and bovine coccidiosis, NWRC researchers collected samples from European starlings at concentrated animal feeding operations (CAFOs) in Texas. The researchers screened samples from cattle feed bunks, water troughs, and feces for coccidia to investigate (1) the prevalence of coccidia in starlings using CAFOs, (2) if there is a relationship between bovine coccidiosis and starling numbers, and (3) if coccidian contamination of cattle feed and water is related to the number of starlings observed on CAFOs. Coccidia belonging to the genus *Eimeria* were detected in cattle feces and in one water sample, but no *Eimeria* spp. were detected in European starlings or cattle feed. However, many European starling samples were positive for the genus *Isospora.* The starlings' use of CAFOs did not appear to be associated with coccidia shedding by cattle, and there was no correlation between starling numbers and the contamination of cattle feed and water—suggesting that starlings do not contribute to the amplification and spread of *Eimeria* in CAFOs.
*Project Contact: Alan Franklin*

- **Effects of European Starlings and Ambient Air Temperature on *Salmonella* Contamination at Feedlots.** European starlings' use of CAFOs varies seasonally, with most damage occurring during winter months when insects and other natural foods are typically unavailable. Starling damage at CAFOs includes the direct consumption of cattle feed and possible contamination of feed with both human and cattle pathogens, including *Escherichia coli, Mycobacterium avium paratuberculosis, Chlamydophila psittaci, Histoplasma capsulatum,* and *Salmonella enterica.* Starlings' use of CAFOs varies within the

winter months, which may be related to periodic changes in weather conditions. NWRC researchers investigated whether *S. enterica* contamination of cattle feed was associated with starlings, meteorological conditions, or both starlings and meteorological conditions. Results showed that the probability of detecting *S. enterica* in cattle feed was greatest on the warmest winter days (50 °F/10 °C) in feed bunks containing the greatest number of starlings (greater than 500 birds). In addition, results indicated that starlings were more abundant at CAFOs on the coldest days. This combination of phenomena led to the conclusion that although starlings were more abundant on colder days, they presented greater risks for spreading *S. enterica* to cattle feed on the warmest winter days. A common metrological scenario for increased risks of *S. enterica* contamination of cattle feed by starlings would be a series of warm days, followed by cold days, then followed by warm days. Because this scenario is more likely associated with late winter and early spring, NWRC researchers recommended that starling control operations at CAFOs be conducted as early in the winter as possible to mitigate the disease risk.
*Project Contact: George Linz*

- **Great Egrets as Vectors for Virulent Aeronomas Hydrophila Among Catfish Ponds.** Recent severe disease outbreaks in channel catfish aquaculture have been associated with a highly virulent strain of the bacterium Aeronomas hydrophila (VAH). Given that VAH is known to infect birds, NWRC researchers hypothesized that fish-eating birds may serve as a reservoir for VAH and spread the pathogen from pond to pond. NWRC researchers conducted experimental studies that showed that great egrets that were fed VAH-infected catfish shed viable VAH. Shedding occurred up to 2 days after the birds were switched to a noninfected fish diet. At necropsy on day 7, nasal swabs from two great egrets were VAH-positive. Great egrets show strong potential as vectors for VAH transmission to catfish ponds. Furthermore, the VAH colonization of the birds' nasal passages suggests that fish-eating birds could serve as a reservoir for the pathogen.
*Project Contact: Fred Cunningham*

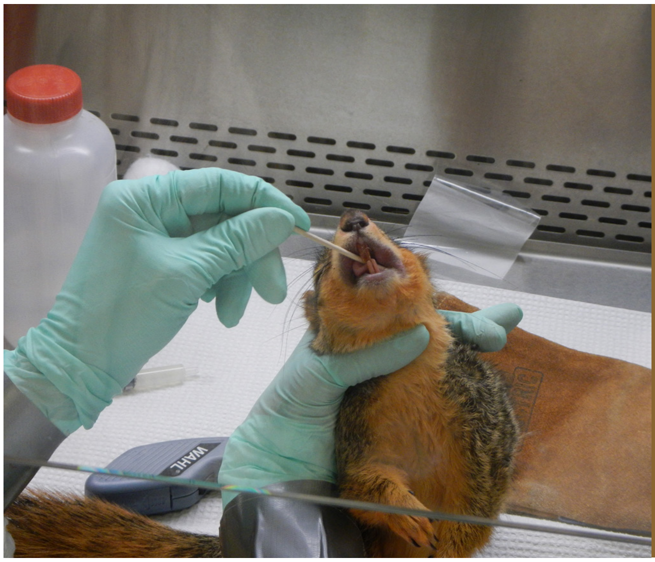
- **Role of Environmental Metals in CWD Transmission.** Understanding the role of environmental metals such as divalent cations (i.e., atoms missing two electrons) in the spread of CWD can provide valuable information for assessing risk and may lead to CWD therapies and prevention through dietary manipulation. NWRC researchers collected environmental samples from CWD-negative and CWD-positive ranches in Colorado and Canada and conducted a cation analysis. The researchers detected a statistically significant difference between cation ratios in positive and negative ranches. Based on this information, a bioassay was conducted utilizing CWD-inoculated, cervidized transgenic mice (i.e., mice containing deer genes) that were given either normal rodent food and normal water or a cation-modified diet and cation-modified water. CWD-inoculated mice on the cation-modified diet lived significantly longer than those on the normal diet. These finding are significant considering that the mode of inoculation (intracerebrally) and dose were both unnatural, suggesting that the effects may be more pronounced in a host species (deer or elk) inoculated in a more natural manner. Work is currently underway to determine the mechanism responsible for these effects as well as the effect of dietary supplementation of omega fatty acids in the mouse model.
*Project Contact: Kurt VerCauteren*

- **Intranasal CWD Inoculation of White-Tailed Deer.** Determining all potential CWD transmission routes in wild animals is important in controlling and preventing the disease. One method of transmission

**Chemistry and genetics experts support NWRC research and development related to repellents, toxicants, vaccines, metapopulation dynamics, disease surveillance, and other wildlife damage management tools and techniques.**
*Photo by USDA, Richard Engeman*

demonstrated experimentally has been the inoculation of massive dosages into the oral cavity. Based on pathological data, this route of infection does not seem to be compatible with the naturally occurring disease. If the CWD prion is located in the dirt and dust surrounding the farm, inhaling these particles may cause disease. Fourteen white-tailed deer were intranasally inoculated 6 times at 1 week apart with a mixture of either CWD-positive (12 deer) or CWD-negative (2 deer) brain homogenate and a montmorillonite clay dust carrier. The deer were euthanized and samples were collected at necropsy for immunohistochemistry analysis. Results show that montmorillonite clay dust is an efficient carrier of CWD. Positive tissues were observed in deer as early as 98 days after the last inoculation. This verifies that the intranasal route is a viable route of infection and that dust, a natural route of exposure, is capable of delivering the infected material intranasally.
*Project Contact: Kurt VerCauteren*

- **Safety and Efficacy of ONRAB® in Target and Nontarget Species.** NWRC researchers are exploring a new oral rabies vaccine (ORV) called ONRAB for use on raccoons and skunks in the United States. In an initial field trial in West Virginia, ONRAB resulted in the highest seroconversion rate in raccoons ever observed for an ORV bait used in the United States, with 49.4 percent of raccoons showing seroconversion post-ORV versus 9.6 percent pre-ORV. Unfortunately, the skunk sample size was too low to adequately assess the effects of the vaccine on skunks. In addition to conducting field trials with the target species, researchers investigated the effects of the vaccine on nontarget species including wood rats, eastern cottontail rabbits, opossums, eastern wild turkey, and fox squirrels. These are all novel species whose habitats overlap with ORV target species. In studies with captive animals, NWRC researchers tested fecal and oral swabs from animals dosed with the ONRAB vaccine at 10 times the rate that they could be exposed to in the wild. Viral ribonucleic acid (RNA) was detected in turkey feces up to 3 days post inoculation (dpi), opossum feces up to




**Studies with captive fox squirrel showed no negative effects from squirrels feeding on ONRAB®, a new oral rabies vaccine bait.**
*Photo by USDA, Shylo Johnson*

6 dpi, cottontail feces up to 5 dpi, and fox squirrel feces through 7 dpi. Although over 40 percent of fox squirrels were still shedding viral RNA on 7 dpi, some showed signs of co-infections with *Leptospira* spp. This co-infection may have made them more susceptible to the vaccine or may have interfered with the test, resulting in false-positives. Minimal shedding was observed via oral routes and opossum nasal swabs, demonstrating that ONRAB has very minimal and temporary impacts on these nontarget species even when exposed to 10 times the expected dose.
*Project Contact: Kurt VerCauteren*

**An EPA registration application has been submitted for the use of NWRC's GonaCon™ immunocontraceptive vaccine to manage fertility in wild horses and burros.**
*Photo by BLM*

## Registration Updates

- **Use of GonaCon™ on Wild Horses.** In May 2012, the NWRC Registration Unit prepared and submitted a registration application to EPA for the use of the GonaCon immunocontraceptive vaccine to manage fertility in wild and feral horses and burros. Once registered, the vaccine will be available for use by employees of APHIS' WS and Veterinary Services programs, the U.S. Bureau of Land Management (BLM), the U.S. Fish and Wildlife Service, the U.S. National Park Service, the U.S. Department of Defense, federally recognized Indian tribes, State agencies responsible for wild or feral horse and burro management, public and private wild horse sanctuaries, or persons working under their authority. Delivery of the product will be by hand injection, jab stick, and darting.
*Project Contact: John Eisemann*

- **Experimental Use Permit for GonaCon: Bison Study.** Preliminary laboratory data indicate that GonaCon is an effective contraceptive for use in bison and potentially has the secondary effect of slowing the spread of brucellosis, an infectious disease affecting bison, elk, cattle, and many other mammals. Consequently, WS and Veterinary Services initiated a joint field study in southern Colorado to evaluate the contraceptive efficacy and duration of GonaCon in bison under free-ranging conditions. The study complements an ongoing study in Montana that tests GonaCon as a means of slowing the spread of brucellosis in bison. If these studies demonstrate that GonaCon is effective in bison, APHIS will likely request a product registration from EPA.
*Project Contact: John Eisemann*

- **EPA Registration Review.** In 2011, EPA continued reevaluating several of the pesticide labels held by APHIS for use by WS and other programs within the agency. EPA's reevaluation considers the adequacy of existing data to support current label claims for sodium cyanide (used in M-44 devices), sodium fluoroacetate (used in Livestock Protection Collars), 3-chloro-p-toluidine hydrochloride (used in DRC-1339 products), sodium nitrate and carbon (used in gas cartridge products), methiocarb (used as an avian repellent), and acetaminophen (used for the control of brown treesnakes). NWRC and the WS Pesticide Coordinating Committee provided all required data for sodium cyanide, sodium fluoroacetate, methiocarb, and acetaminophen to EPA, and they do not anticipate any major changes in the status of these products.

EPA has requested a significant amount of information on WS' use of DRC-1339 and gas cartridge products and, in some cases, data to support their use. EPA has requested that APHIS submit results from more than 20 additional studies, at an approximate cost of $2.2 million, to support the continued use of DRC-1339 products. APHIS has responded by submitting information that characterizes WS' use of DRC-1339, agreeing to modify allowable use patterns and submitting existing published and unpublished literature in support of these data requirements.

EPA has not requested additional data to support the current registrations of sodium nitrate and carbon when used in gas cartridges. However, as part of its efforts to strengthen its programs to protect threatened and endangered species, EPA is implementing a new Web-based system, known as Bulletins Live, to identify geographic areas where use of these products would be prohibited. APHIS is working with EPA to ensure that geographic restrictions also include reasonable consideration for animal behaviors and seasonal occurrences, which would allow the use of these important tools without negatively impacting threatened and endangered species.
*Project Contact: John Eisemann*

## Technology Transfer

- **Transferring GonaCon Registration Data to FERA for Use on European Badgers.** NWRC and the United Kingdom's (UK) Food and Environment Research Agency (FERA) have worked collaboratively to test wildlife contraceptives. In particular, FERA is interested in using GonaCon to reduce population levels of European badgers, a protected species in the UK. European badgers can cause extensive property damage by digging around buildings, and they are a primary reservoir for bTB in the UK. GonaCon has been investigated as a potential alternative to culling badgers and as a technique that could be used in conjunction with bTB vaccinations to reduce bTB prevalence in badgers. NWRC has provided registration data to FERA, which is interested in producing GonaCon for use in badgers and other feral animals. However, because the UK has a regulatory system for wildlife contraceptive products that registers wildlife products as drugs rather than pesticides, the cost for GonaCon registration for wildlife would be prohibitively high for these limited uses. FERA and NWRC are investigating how to provide a product for the UK.
*Project Contact: Kathleen Fagerstone*

- **Live-Catch Beaver Trap.** In December 2011, WS filed a patent application for a live-catch beaver trap that closes by gravity. The trap is designed to be easier to set and safer than spring traps that are currently available for sale. They are also expected to be cheaper to manufacture than other traps.
*Project Contact: Kathleen Fagerstone*

- **Animal Leg Snare Device.** On December 20, 2011, WS was issued a U.S. patent for an animal leg snare device. This device uses a mechanical throw arm that, when triggered by an animal of sufficient size stepping on the pan, throws a snare up and around the leg of the animal. The pan tension of the device can be adjusted to avoid being triggered by lighter weight nontarget animals. If the device is triggered by a larger, stronger nontarget animal, the apparatus includes a break-away snare to allow the animal to escape.
*Project Contact: Kathleen Fagerstone*

- **New Cooperative Research and Development Agreements.** NWRC scientists signed three new Cooperative Research and Development Agreements (CRADAs) during fiscal year 2012 with

**NWRC experts co-hosted the first Northern Colorado Technology Transfer Fair in Fort Collins, CO. The free event highlighted Government-industry partnerships.**
*Photo by USDA, Gail Keirn*

private companies and foreign governments for conducting joint research to develop and commercialize inventions. Research activities under these agreements include the development of injectable or oral immunocontraceptive vaccines and the testing of those vaccines in European wildlife species. In addition, NWRC researchers are collaborating with a private company to develop a prototype species-specific acoustic recognition system. This recognition system would allow the delivery of disease vaccines, contraceptives, or toxicants to only the species of interest. The first application of the recognition system to be developed and tested will focus on the delivery of products for feral swine population and disease control. Currently, NWRC is participating in 10 CRADA projects.
*Project Contact: Kathleen Fagerstone*

- **Northern Colorado Technology Transfer Fair.** On August 7, 2012, NWRC partnered with four other Federal research laboratories in northern Colorado to host the 2012 Northern Colorado Technology Transfer Fair at the Drake Center in Fort Collins, CO. This free, 1-day event showcased Federal research to encourage new partnerships and collaborations and create opportunities for economic growth and innovation in northern Colorado and southern Wyoming. Approximately 170 people attended the fair, including business owners, entrepreneurs, academics, congressional staffers, Federal and State government researchers, and representatives from numerous economic development entities. This was the first technology transfer fair hosted in northern Colorado to highlight the expertise of Federal research laboratories in Larimer County and other nearby locations. The event had a tradeshow atmosphere with case studies of effective industry-Federal Government partnerships; booths highlighting Federal expertise and available technologies related to agriculture, bioscience, clean energy, and natural resources; and discussions on how to partner with Federal labs. The event was hosted by NWRC, the U.S. Department of Health and Human Services' Centers for Disease Control and Prevention, the U.S. Department of Energy's National Renewable Energy Laboratory, USDA's Agricultural Research Service, and USDA's Forest Service. Local government and private groups sponsored the event and provided refreshments.

## Awards

- **2011 NWRC Publication Awards.** NWRC scientists Stewart Breck, Alan Franklin, George Linz, James Carlson, and Susan Petit were honored with the 2011 NWRC Publication Awards. These awards are given annually at NWRC to recognize quality research published within the previous year.

  In the article "Domestic Calf Mortality and Producer Detection Rates in the Mexican Wolf Recovery Area: Implications for Livestock Management and Carnivore Compensation Schemes" *(Biological Conservation),* Breck and collaborators addressed factors underlying conflict between carnivore conservation and livestock depredation and posed evidence-based management solutions to reduce this conflict. Specifically, the authors radio-tagged calves on two sites within a Mexican wolf recovery area to investigate factors that influence calf mortality and producer depredation detection rates. Results from nearly 1,000 tagged calves during the 3.5-year effort indicate that year-round calving was associated with higher depredation rates, likely due to longer exposures to predation risk. Consequently, the authors recommended that ranchers use seasonal calving to reduce depredation. The authors also found that production detection rates can be so highly variable that producer reporting may be unreliable and verification compensation programs may be unfair if producer monitoring efforts are not considered. The authors recommended a performance-payment scheme for operator compensation based on conservation outcomes and expected carnivore damage. This article was recognized for its creative and rigorous approach to an important management question, the strong collaborative effort representing a number of diverse institutions, and its publication in a high-quality scientific journal.

In "The Role of Starlings in the Spread of Salmonella Within Concentrated Animal Feeding Operations" *(Journal of Applied Ecology),* Carlson, Franklin, Linz, and Petit characterized and provided management recommendations for mitigating the disease risks associated with wildlife use of CAFOs. The authors combined both field evaluations and sampling with laboratory analysis to evaluate the prevalence of *S. enterica* in European starlings using CAFOs and the relationship between starling numbers, *S. enterica* contamination in cattle feed and water, and cattle infections. The authors found that the numbers of starlings better explained *S. enterica* contamination of cattle feed and water than other variables, including cattle stocking, facility management, and environmental variables. Accordingly, they concluded that starlings were a source of *S. enterica* contamination in CAFOs. Their findings provide important support for starling management tools to reduce the amplification and spread of disease within livestock production systems. This publication was recognized for NWRC scientists' significant contribution, the synergistic combination of large-scale field study and laboratory analyses, its high technical and literary quality, the comprehensiveness of its design, and its value to the field of wildlife damage management.

- **NWRC Employee of the Year Awards.** The winners of this award are nominated by their peers as employees who have clearly exceeded expectations in their contributions toward the Center's mission. The winners this year are listed below.

    - **George M. Linz,** Research Grade Scientist, Methods Development and Population Biology of Blackbirds and Starlings in Conflict with Agriculture, Concentrated Animal Feeding Operations, and Urban Environments Project, Bismarck, ND

    - **Thomas W. Seamans,** Support Scientist, Development of Management Strategies to Reduce Wildlife Hazards to Aircraft Project, Sandusky, OH

    - **Daniel N. Gossett,** Technician, Animal Care Unit, Fort Collins, CO

    - **Cherryl J. Tope,** Administration, Administrative Support Unit, Fort Collins, CO

- **Partners in Conservation Award.** In September 2012, Michael Avery and John Humphreys from the NWRC Florida field station were recognized for their contributions to the Everglades Cooperative Invasive Species Management Area (ECISMA) when the ECISMA was honored with the U.S. Department of the Interior's Partners in Conservation Award. NWRC is an active member of the ECISMA and assists in efforts to protect the Everglades ecosystem from the impacts of invasive animal species such as the Nile monitor lizard, North African rock python, and sacred ibis. The ECISMA is recognized nationally as an exemplary model for effective cooperative invasive species management and is composed of representatives from 18 Federal agencies, the State of Florida, tribal and local governments, nongovernmental organizations, universities, and private citizens.

# 2012 Publications

The transfer of scientific information is an important part of the research process. NWRC scientists publish in a variety of peer-reviewed journals that cover a wide range of disciplines, including wildlife management, genetics, analytical chemistry, ornithology, and ecology. Names highlighted in bold are NWRC employees. (Note: 2011 publications that were not included in the 2011 NWRC accomplishments report are listed here.)


Allen, B.L.; Fleming, P.J.S.; Hayward, M.; Allen, L.R.; **Engeman, R.M.;** Ballard, G.; Leung, L.K.P. 2012. Top-predators as biodiversity regulators: contemporary issues affecting knowledge and management of dingoes in Australia. In: Lameed, G.A., editor. *Biodiversity Enrichment in a Diverse World.* InTech.: 85–132.

**Anderson, A.; Shwiff, S.; Gebhardt, K.;** Ramirez, A.J.; **Kohler, D.;** Lecuona, L. 2012. Economic evaluation of vampire bat *(Desmodus rotundus)* rabies prevention in Mexico. *Transboundary and Emerging Diseases.* doi: 10.1111/tbed.12007.

Annala, M.; **Tillman, E.A.** 2012. Crow pellets from winter roosts in Lancaster, Pennsylvania. *Northeastern Naturalist* 19: 527–532.

**Avery, M.L.; Tillman, E.A.; Keacher, K.L.;** Arnett, J.E.; Lundy, K.J. 2012. Biology of invasive monk parakeets in south Florida. *The Wilson Journal of Ornithology* 124: 581–588.

Bai, Y.; Calisher, C.H.; Kosoy, M.Y.; **Root, J.J.;** Doty, J.B. 2011. Persistent infection or successive reinfection of deer mice with *Bartonella vinsonii subsp. arupensis. Applied and Environmental Microbiology* 77(5): 1728–1731.

Baker, J.M.; **Shivik, J.;** Jordan, K.E. 2011. Tracking of food quantity by coyotes *(Canis latrans). Behavioural Processes* 88: 72–75.

Beasley, J.C.; Beatty, W.S.; **Atwood, T.C.; Johnson, S.R.; Rhodes, Jr., O.E.** 2012. A comparison of methods for estimating raccoon abundance: implications for disease vaccination programs. *Journal of Wildlife Management* 76: 1290–1297.

Beasley, J.C.; Olson, Z.H.; **Devault, T.L.** 2012. Carrion cycling in food webs: comparisons among terrestrial and marine ecosystems. *Oikos* 121: 1021–1026.

Beatty, W.S.; Beasley, J.C.; Dharmarajan, G.; **Rhodes, Jr., O.E.** 2012. Genetic structure of a Virginia opossum *(Didelphis virginiana)* population inhabiting a fragmented agricultural ecosystem. *Canadian Journal of Zoology* 90: 101–109.

**Bentler, K.T.; Gossett, D.N.; Root, J.J.** 2012. A novel isoflurane anesthesia induction system for raccoons. *Wildlife Society Bulletin.* doi: 10.1002/wsb.193.

Berg, N.D.; **Gese, E.M.;** Squires, J.R.; Aubry, L.M. 2012. Influence of forest structure on the abundance of snowshoe hares in western Wyoming. *Journal of Wildlife Management* 76: 1480–1488.

**Bevins, S.N.; Baroch, J.A.; Nolte, D.L.;** Zhang, M.; He, H. 2012. Yersinia pestis: examining wildlife plague surveillance in China and the USA. *Integrative Zoology* 7: 99–109.

**Bevins, S.N.;** Carver, S.; Boydston, E.E.; Lyren, L.M.; Alldredge, M.; Logan, K.A.; Riley, S.P.D.; Fisher, R.N.; Vickers, T.W.; Boyce, W.; Salman, M.; Lappin, M.R.; Crooks, K.R.; Vandewoude, S. 2012. Three pathogens in sympatric populations of pumas, bobcats, and domestic cats: implications for infectious disease transmission. *PloS One* 7: e31403. doi: 10.1371/journal.pone0031403.

Biggins, D.E.; Hanebury, L.R.; **Fagerstone, K.A.** 2012. Digging behaviors of radio-tagged black-footed ferrets near Meeteetse, Wyoming, 1981–1984. *Western North American Naturalist* 72: 148–157.

**Blackwell, B.F.; DeVault, T.L.; Seamans, T.W.;** Lima, S.L.; Baumhardt, P.; Fernández-Juricic, E. 2012. Exploiting avian vision with aircraft lighting to reduce bird strikes. *Journal of Applied Ecology* 49: 758–766.

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# Appendix 1

## List of 2012 NWRC Research Projects

Avian and Invasive Species Population Management
*Project Leader: Michael Avery*

Defining Economic Impacts and Developing Strategies for Reducing Avian Predation in Aquaculture Systems
*Project Leader: Fred Cunningham*

Defining Impacts and Developing Strategies To Reduce Mammalian Damage in Forested and Riparian Ecosystems
*Project Leader: Jimmy Taylor*

Developing Control Methods, Evaluating Impacts, and Applying Ecology, Behavior, Genetics, and Demographics To Manage Predators
*Project Leader: Julie Young*

Development of Injectable and Oral Contraceptive Technologies and Their Assessment for Wildlife Populations and Disease Management
*Project Leader: Lowell Miller*

Development of Management Strategies To Reduce Wildlife Hazards to Aircraft
*Project Leader: Travis DeVault*

Development of Methods To Control Rodent Populations and Damage With an Emphasis on Invasive House Mice and Native Voles
*Project Leader: Gary Witmer*

Ecology of Emerging Viral and Bacterial Diseases in Wildlife
*Project Leader: Alan Franklin*

Economic Research of Human-Wildlife Conflicts: Methods and Applications
*Project Leader: Stephanie Shwiff*

Feral Swine Damage Control Strategies
*Project Leader: Tyler Campbell*

Investigating the Ecology, Control, and Prevention of Terrestrial Rabies in Free-Ranging Wildlife
*Project Leader: Kurt VerCauteren*

Management of Ungulate Disease and Damage
*Project Leader: Kurt VerCauteren*

Methods and Strategies To Manage Invasive Species Impacts to Agriculture, Natural Resources, and Human Health and Safety
*Project Leader: William Pitt*

Methods Development and Population Biology of Blackbirds and Starlings in Conflict with Agriculture, Concentrated Animal Feeding Operations, and Urban Environments
*Project Leader: George Linz*

Use of Chemistry, Biochemistry, Computational Modeling, and Chemosensory Research To Develop Wildlife Damage Management Tools
*Project Leader: Bruce Kimball*

More information about these projects can be found on the NWRC Web page at:
**www.aphis.usda.gov/wildlife_damage/nwrc/**

# Appendix 2

## NWRC Research Contacts

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| Breck, Stewart | (970) 266-6092<br>*Stewart.W.Breck@aphis.usda.gov* | Carnivores |
| Campbell, Tyler | (352) 375-2229<br>*Tyler.A.Campbell@aphis.usda.gov* | Project Leader: feral swine, pseudorabies |
| Cunningham, Fred | (662) 325-8215<br>*Fred.L.Cunningham@aphis.usda.gov* | Project Leader: aquaculture, cormorants |
| DeVault, Travis | (419) 625-0242 ext. 11<br>*Travis.L.DeVault@aphis.usda.gov* | Project Leader: aviation hazards |
| Dorr, Brian | (662) 325-8216<br>*Brian.S.Dorr@aphis.usda.gov* | Aquaculture, cormorants |
| Dwyer, Diana | (970) 266-6015<br>*Diana.L.Dwyer@aphis.usda.gov* | Information Services Unit Leader: library, Web, archives |
| Eisemann, John | (970) 266-6158<br>*John.D.Eisemann@aphis.usda.gov* | Registration Unit Leader: product registration |
| Engeman, Richard | (970) 266-6091<br>*Richard.M.Engeman@aphis.usda.gov* | Statistics, invasive species, population indexing |
| Fagerstone, Kathleen | (970) 266-6161<br>*Kathleen.A.Fagerstone@aphis.usda.gov* | Technology transfer, product registration, wildlife contraceptives |
| Franklin, Alan | (970) 266-6137<br>*Alan.B.Franklin@aphis.usda.gov* | Project Leader: emerging infectious diseases |
| Gese, Eric | (435) 797-2542<br>*Eric.M.Gese@aphis.usda.gov* | Carnivores |
| Gionfriddo, Jim | (970) 266-6146<br>*James.P.Gionfriddo@aphis.usda.gov* | Wildlife contraceptives, deer, squirrels |
| Homan, Jeff | (701) 250-4467 ext. 2<br>*Jeffrey.H.Homan@aphis.usda.gov* | Bird damage to agriculture, bioenergetics models |
| Horak, Katherine | (970) 266-6168<br>*Katherine.E.Horak@aphis.usda.gov* | Physiological modeling, pesticides |
| Keirn, Gail | (970) 266-6007<br>*Gail.M.Keirn@aphis.usda.gov* | Legislative and Public Affairs |

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| King, Tommy | (662) 325-8314<br>*Tommy.King@aphis.usda.gov* | Aquaculture, cormorants, pelicans |
| Linz, George | (701) 250-4469 ext. 3<br>*George.M.Linz@aphis.usda.gov* | Project Leader: bird damage to agriculture |
| Miller, Lowell | (970) 266-6163<br>*Lowell.A.Miller@aphis.usda.gov* | Project Leader: wildlife contraceptives, GonaCon™ |
| Piaggio, Toni | (970) 266-6142<br>*Toni.J.Piaggio@aphis.usda.gov* | Genetics |
| Pitt, William | (808) 961-4482 ext. 22<br>*Will.Pitt@aphis.usda.gov* | Project Leader: invasive species, Hawaii, Guam |
| Root, Jeff | (970) 266-6050<br>*Jeff.Root@aphis.usda.gov* | Wildlife diseases |
| Shriner, Susan | (970) 266-6151<br>*Susan.A.Shriner@aphis.usda.gov* | Disease modeling |
| Shwiff, Stephanie | (970) 266-6150<br>*Stephanie.A.Shwiff@aphis.usda.gov* | Project Leader: economics |
| Stahl, Randal | (970) 266-6062<br>*Randal.S.Stahl@aphis.usda.gov* | Chemistry |
| Taylor, Jimmy | (541) 737-1353<br>*Jimmy.D.Taylor@aphis.usda.gov* | Project Leader: forestry, beaver |
| VerCauteren, Kurt | (970) 266-6093<br>*Kurt.C.VerCauteren@aphis.usda.gov* | Project Leader: cervids, chronic wasting disease, barriers, rabies |
| Washburn, Brian | (419) 625-0242 ext. 12<br>*Brian.E.Washburn@aphis.usda.gov* | Aviation hazards, bird movements |
| Werner, Scott | (970) 266-6136<br>*Scott.J.Werner@aphis.usda.gov* | Bird damage to agriculture, repellents |
| Witmer, Gary | (970) 266-6335<br>*Gary.W.Witmer@aphis.usda.gov* | Project Leader: rodents, rodenticides, invasive species |
| Young, Julie | (435) 797-1348<br>*Julie.K.Young@aphis.usda.gov* | Project Leader: carnivores |

# Appendix 3

## Acronyms and Abbreviations

| | |
|---|---|
| **AIV** | Avian influenza virus |
| **APHIS** | Animal and Plant Health Inspection Service |
| **bTB** | Bovine tuberculosis |
| **CAFOs** | Concentrated animal feeding operations |
| **CRADA** | Cooperative Research and Development Agreement |
| **CSF** | Cerebral spinal fluid |
| **CWD** | Chronic wasting disease |
| **DPI** | Days post inoculation |
| **DPN** | Diphacinone |
| **EPA** | U.S. Environmental Protection Agency |
| **FERA** | United Kingdom's Food and Environmental Research Agency |
| **FY** | Fiscal year |
| **GonaCon** | GonaCon™ immunocontraceptive vaccine |
| **LPS** | Lipopolysaccharide |
| **NWDP** | National Wildlife Disease Program |
| **NWRC** | National Wildlife Research Center |
| **ORV** | Oral Rabies Vaccination |
| **PMCA** | Protein misfolding cyclic amplification |
| **RNA** | Ribonucleic acid |
| **RV** | Rabies-vaccinated |
| **USDA** | U.S. Department of Agriculture |
| **VAH** | Virulent Aeromonas hydrophila |
| **VOCs** | Volatile organic compounds |
| **WNV** | West Nile virus |
| **WS** | Wildlife Services |

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